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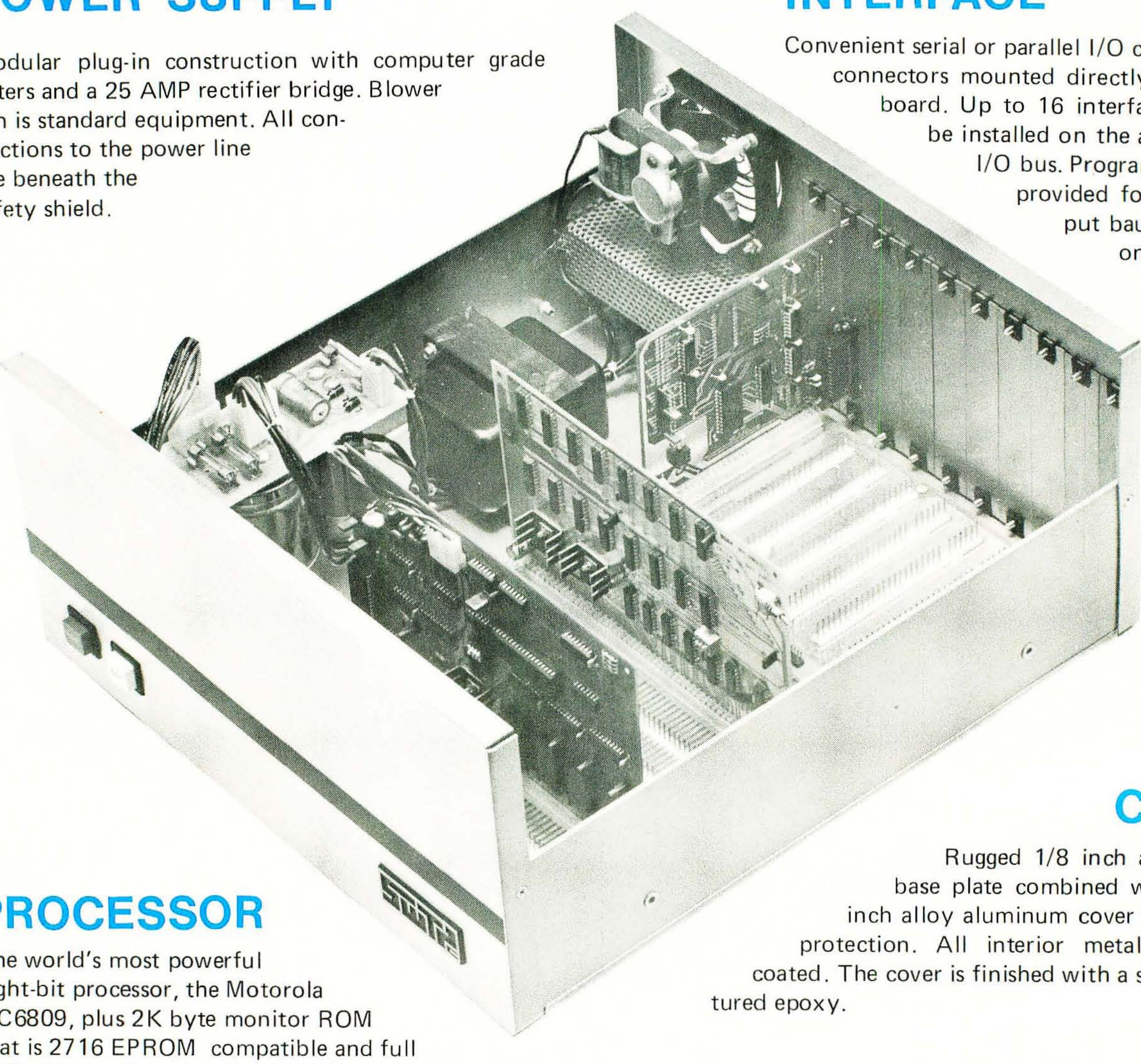
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GRAPH THEORY





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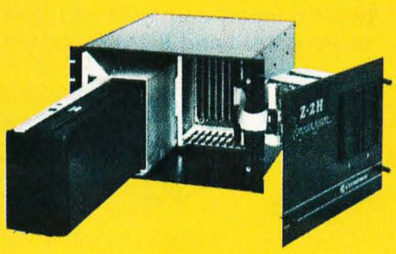
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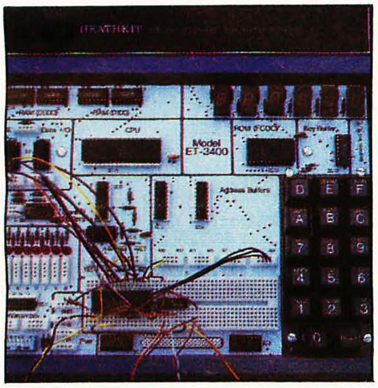
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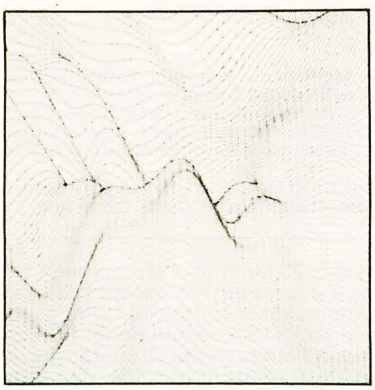
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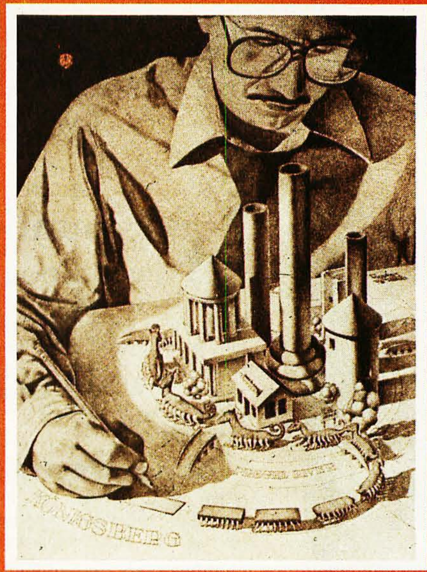
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ON THE COVER

Topology is the theme of this month's cover painting, "The Seven Bridges of Königsberg" by Robert Tinney. It is a fanciful representation of a classical, topological problem made famous by the Swiss mathematician Euler, and it has a more than passing resemblance to the works of the Swiss artist M C Escher. The celebrated problem is discussed in detail by Carl Helmers in this month's editorial, and the painting is also loosely inspired by the theme article, "A First Look at Graph Theory Applications," by Ashbrook and Zinn. Sharp-eyed readers might spot a visual reference to another famous mathematical problem hidden in the cover.

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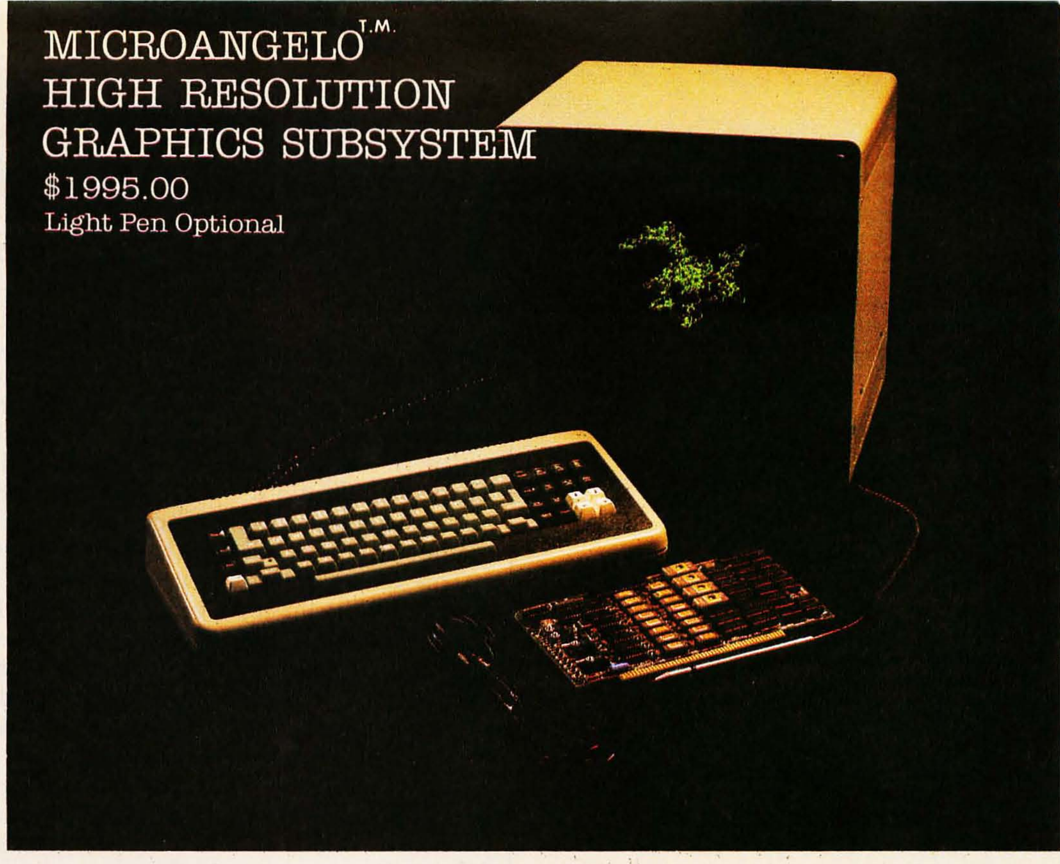
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Editorial

The Seven Bridges of Königsberg

by Carl Helmers

Covers, like editorial themes, are sometimes drawn from interesting subjects intended as themes for an issue. But divergences can occur. This month, the nominal theme for the issue is the topic of graph theory. It takes only one article to suggest such a cover theme, and the article "A First Look at Graph Theory Applications " by Michael Ashbrook and Helmut Zinn provided the initial suggestion. But our actual cover is inspired by a historical problem in mathematics which led to the definition of a much broader field: topology.

This generalization occurred as a result of trying to find a nice neat visual image that fits the topic of graph theory. In order to concoct a cover idea on graph theory, the first step is to start searching around for some theme on a diagram of nodes and interconnecting segments which is not some hackneyed abstract pun. In order to construct a visual image for a cover, I needed to find some seminal problem with dramatic visual import. This problem must define and suggest the general field of endeavor. So, I proceeded to hunt around.

A good forest in which to hunt mathematical images is an excellent four-volume set of books entitled *The World of Mathematics*, by James R Newman, published by Simon and Schuster in 1956, and still available at a cost of $39.95. On the covers of the four volumes we find the description "a small library of the literature of mathematics, from A'h-mose the Scribe to Albert Einstein, presented with commentaries and notes." These books present a selection of original papers by mathematicians, with introductions and commentary by the editor. As serious or recreational reading for those interested in mathematical subjects, I highly recommend it.

So, naturally, I turned to the index of Mr Newman's book. I knew that somewhere in that 2535-page work I might find some visual image with which artist Robert Tinney could work to create a cover. It did not take long to find the appropriate image. On pages 570 thru 599 we find Mr Newman's commentary on graph theory, which is really an illustrative subset of a much more general field, topology. Following three pages of editor's commentary, the two papers reproduced in this section of the book are Leonhard Euler's memoir "The Seven Bridges of Königsberg" (1735) and a survey article "Topology," by Richard Courant and Herbert Robbins, taken from their book *What Is Mathematics?* (Oxford University Press, 1941). When I encountered the problem of the Seven Bridges of Königsberg in the form of Euler's paper, I knew we had a cover image.

The problem is quite simply stated: a city, Königsberg, is built on an island in the river Pregel (see figure 1). We wish to find out if it is possible to cross all seven bridges in an afternoon's walk without crossing any bridge more than once.

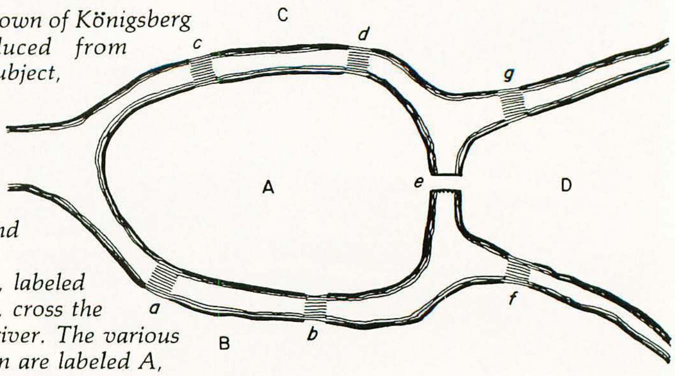


Figure 1: *Map of the town of Königsberg in Prussia, reproduced from Euler's paper on the subject, first published in 1735. Within the town there is an island called Kneiphof, labeled A in the figure, around which flows the river Pregel. Seven bridges, labeled a, b, c, d, e, f, and g, cross the two branches of the river. The various land areas of the town are labeled A, B, C, and D.*

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What Euler did, in an eminently readable argument in his paper, is to prove that it is indeed *not* possible. He proves that the popular hobby of the Königsberg folk of seeking that magic path could never succeed. In so doing, he helped to found the science of topology. According to Newman in his commentary on the paper,

> *The problem — to cross the seven bridges in a continuous walk without recrossing any of them — was regarded as a small amusement of the Königsberg townsfolk. Euler, however, discovered an important scientific principle concealed in the puzzle. He presented his simple and ingenious solution to the Russian Academy at St Petersburg in 1735. His method was to replace the land areas by points and the bridges by lines connecting these points. The points are called vertices; a vertex is called odd or even according as the number of lines leading from it are odd or even. The entire configuration is a graph; the problem of crossing the bridges reduces to that of traversing the graph with one continous sweep of the pencil without lifting it from the paper. If the graph contains more than two* odd *vertices, it may be traversed in one journey but it is not possible to return to the starting point. The general principle is that if the graph contains* 2n *odd vertices where* n *is any integer, it will require exactly* n *distinct journeys to traverse it. . . .*
>
> *Thus began a "vast and intricate theory [topology]," still young and growing, yet already one of the great forces of modern mathematics.*

Now we had the general outline of the image. Fine details remained to be worked out with Robert. Now, Robert Tinney and I know of a number of artists that we regard as extremely interesting in general style and subject mater. There are, for example, the direct and conscious influences of Maxfield Parrish and Norman Rockwell on Robert's style of painting as often seen in covers of BYTE. However, we have of late been getting immersed in the fascinating art of M C Escher. Part of this fascination has been lying dormant since Martin Gardner's series of articles on Escher and tesselations of the plane in *Scientific American* (see his "Mathematical Games" column in the July 1975 (page 112), August 1975 (page 112), December 1975 (page 116), January 1977 (page 110), and June 1978 (page 18) issues). The fascination is of course greatly rekindled by the recent publication of the book *Gödel, Escher, Bach* by computer scientist Douglas R Hofstadter.

So, given the theme of the seven bridges of Königsberg, the added input of a recursive-programming computer-science pun clearly evident in the image, and a fascination with Escher's style, Robert chose to produce a cover image inspired by the art of Escher. The result is what you see. ■

In Next Month's BYTE

The March 1980 BYTE will be devoted to "Computers and the Sciences." The theme articles will cover diverse topics such as "Electron Behavior in Chemical Bonds," "Electronic Planimetry," "Chemistry Program for the Apple Computer," and a "Derailleur Speed-Calculation Program."

An Update on Direct Cursor Addressing and UCSD Pascal

In last month's editorial on the Apple Pascal system, I made some comments about difficulties in getting the UCSD System to emit the cursor addressing character of my Computer Peripherals Corp "COPS-10" terminal. This terminal requires the sequence of "control-P, <Y+32>, <X+32>" to directly address a given location on the screen.

It turns out that the UCSD Pascal System (not just the Apple II version) gobbles "control-P" characters on output, whether through use of WRITE, WRITELN or even UNITWRITE. Naturally, it became a challenge to find out how to emit a control-P.

So, trying brute force as a first method of solution, I wrote an assembly language program using the UCSD Pascal System's 6502 assembler. This assembly language program simply set up the parameters for the routine "SHOUT" within the Apple II serial card's read-only memory, then called that routine to emit the control-P character. I proved it worked by writing a Pascal GOTOXY procedure and test program.

The UCSD Assembler proved more than adequate for my purposes, in its 6502-oriented version running on the Apple. A most useful feature is its macroinstruction facility with conditional assembly. The Apple documentation of the UCSD System includes examples of assembly language interfaces which proved to be quite a helpful model. There was one convention that I had to worry about for a few assemblies. This was the fact that the assembler only allows hexadecimal integer constants. The assembler also demands uppercase only for tokens, although lowercase works fine in comments.

Of course, the version of the Pascal GOTOXY that used this assembly language procedure had to have an external procedure definition. This presented no problem when compiling without any special compiler options. But the manual points out (and experience confirms) that the "{$U−}" option must be active when compiling the code file that will be linked into the system by BINDER. Every time I try to compile with the required {$U—} compiler toggle, I get a Pascal syntax error #183, "External declaration not allowed at this nesting level." This was in spite of the fact that the "PROCEDURE CTRLP3; EXTERNAL;" sequence is at the outer (PROGRAM) level of nesting.

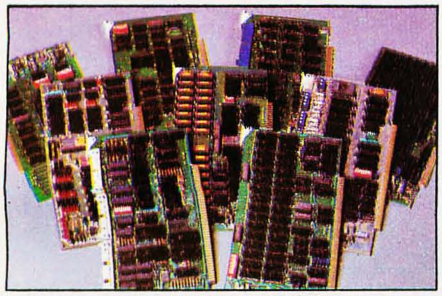
I tried everything I could think of: linking before BINDER, not linking, using it with the {$U} toggle and without, etc, etc. I even recalled the existence of a magical UCSD Pascal compiler toggle "{$T+}", which is required for compilation of super-large systems programs. When used with the {$U−} option, I could get the program to compile and link with the assembly language program—but then BINDER would not accept it. Clearly it was all to no avail. Would I be stuck with the GOTOXY cursor kludge of

<home><LF>. . .<LF><HT>. . .<HT>

forever?

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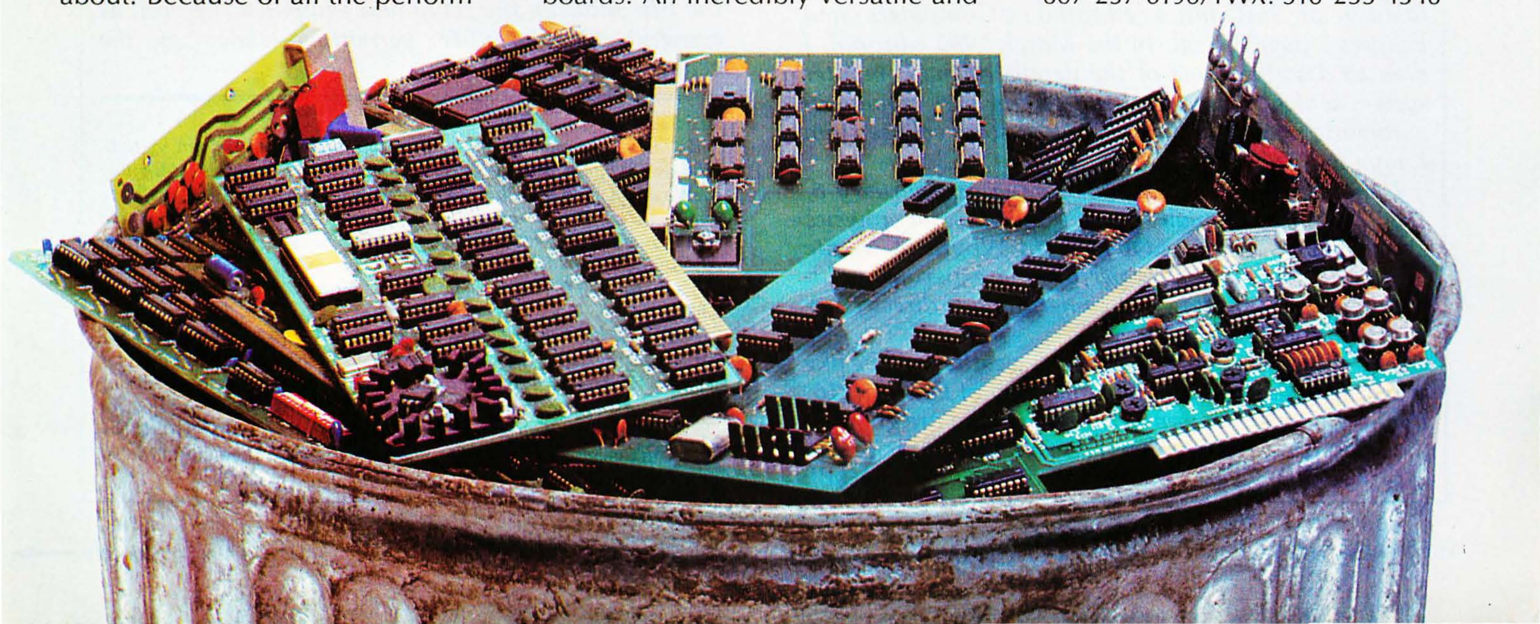
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Well, impossible problems lead to new solutions when frustrations get high enough. One solution would of course be a new terminal that had the necessary cursor control keys (the up/down/left/right arrows) but used a different direct addressing sequence.

On the day I solved the problem, I was talking with Cameron Jones about getting the UCSD Pascal System version for my New England Digital Synclavier music synthesizer. (Cameron Jones, Syndey Alonzo, and Jon Appleton are the co-inventors of the Synclavier.) As the Synclavier and its ABLE/60 computer comes delivered, its native language is XPL. So implementing a UCSD Pascal system becomes a problem of implementing the core interpreter in XPL.

As I was talking on the phone with Cameron, I finally realized what was wrong. The cursor addressing character of my terminal is an ASCII DLE character which is also known as control-P when emitted from a keyboard. And the UCSD System will always eat control-P characters, since this is the spaces-compression escape character of ".TEXT" files! Cameron pointed out that the specification of the UCSD Pascal UNITWRITE routine is that it will do spaces decompression.

So I had to have a character that looks like a control-P to the terminal but not like a control-P to UCSD Pascal. This character is of course a character with the integer value 144. Its value is obtained by turning on the high-order bit in an 8-bit character by adding 128 to the control-P character code's value of 16. While the Pascal program's character data value are 8 bits, the terminal only looks at the low-order 7 bits. Thus, if the low-order looks like a control-P, turning on the high-order bit will keep Pascal from thinking it really is a DLE while allowing the terminal to think it is.

Everything else immediately simplified and fell in place. Listing 1 shows the final version of the GOTOXY procedure, which now emits an 8-bit pseudo- control-P character that gets interpreted by the terminal as a 7-bit control-P character.

Of course, by getting frustrated by this problem, I explored the use of assembly language features of the UCSD System. I learned how to link successfully to assembly language programs, use the macroassembler that comes with the system, and unwind parameters from the Pascal stack in assembly language programs. I will probably never again use an assembly language program with a Pascal program. But if I need to for some reason of speed, I now know it is possible. This short note and this month's editorial were the first texts I edited using the new version of GOTOXY; the results are quite an improvement — I am no longer limited by rather artificial delays required by last month's cursor addressing kludge.

Listing 1:

```
(*$U-*)
PROGRAM GOXY;
   { the final version of the GOTOXY procedure, used with Apple Pascal  }
   {      and the Computer Peripherals Corporation COPS-10 terminal.  The}
   {      ASCII (7 bit) sequence:                                        }
   {                 <ctrl P> <Y+32> <X+32>                              }
   {      causes direct cursor addressing.                               }

   PROCEDURE FGOTOXY(x_axis,y_axis: INTEGER);

   {  COPS 10 - GOTOXY  }

      CONST
         control_P = 144 {high order bit on, but no effect 16+128};
      VAR
         x,y :             INTEGER;
         abyte :           PACKED ARRAY[0..0] OF CHAR;

      BEGIN

         {  ... how do we send a "control P" when the Pascal UNITWRITE will }
         {  gobble it because it thinks that it is spaces compression char- }
         {  acter?  Well, recognize that the terminal only pays atten-      }
         {  tion to 7 low order bits.  Thus if we send a a control P with   }
         {  the high order bit on, then UNITWRITE will say "aha that is not }
         {  a control P" and the terminal will say "aha that is a control P"}
         abyte[0] := CHR(control_P);
         UNITWRITE(1,abyte,1,,1);

         x := x_axis + 32;
         y := y_axis + 32;
         IF x > 111 THEN x := 111; {111 = 79 + 32}
         IF x < 32 THEN x := 32;
         IF y > 55 THEN y := 55;   {55 = 23 + 32}
         IF y < 32 THEN y := 32;
         abyte[0] := CHR(y);
         UNITWRITE(1,abyte,1,,1);
         abyte[0] := CHR(x);
         UNITWRITE(1,abyte,1,,1)
      END {gotoxy};


BEGIN (* DUMMY MAIN *)
END.
(*$U-*)
```

On Eclipses, Next Month's Editorial and the West Coast Computer Faire. . .

As you read this February 1980 issue of BYTE, I will be embarking on a journey to make the technological fantasy of last July's editorial ("Computers and Eclipses," page 8) real. In the March 1980 editorial, I plan to describe some of the details of the computer system which will control my Nikon F2A camera in automatic photography of the 1980 solar eclipse from Kenya in Africa.

I am scheduled to leave for Kenya on February 6, 1980, joining a small expedition of solar physics experimenters organized by Norm Whyte of Monte Rio, California. Norm is performing experiments involving a custom designed camera under direct computer control of an Apple II.

The only uncertainty is what the weather will be like at our observation site on the morning of February 16, 1980. Whatever the weather, readers who are going to the West Coast Computer Faire in San Francisco in March 1980 will be able to see the results in a talk entitled "Microcomputers in Africa: A Travelogue of The 1980 Eclipse."

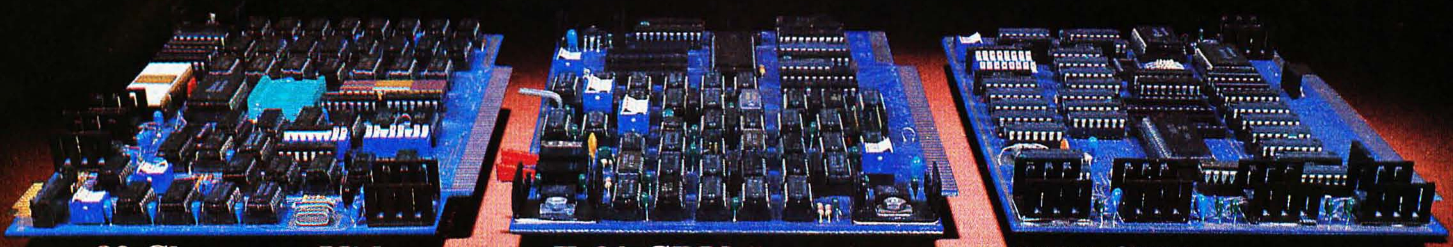
Norm and I will be presenting this talk as part of the technical program. It will feature slides made during the trip showing the setup and equipment (as well as scenery) and—weather permitting—slides of the eclipse itself. . . **.CH**

Articles Policy

BYTE is continually seeking quality manuscripts written by individuals who are applying personal computer systems, designing such systems, or who have knowledge which will prove useful to our readers. For a more formal description of procedures and requirements, potential authors should send a large (9 by 12 inch, 30.5 by 22.8 cm), self-addressed envelope, with 28 cents US postage affixed, to BYTE Author's Guide, 70 Main St, Peterborough NH 03458.

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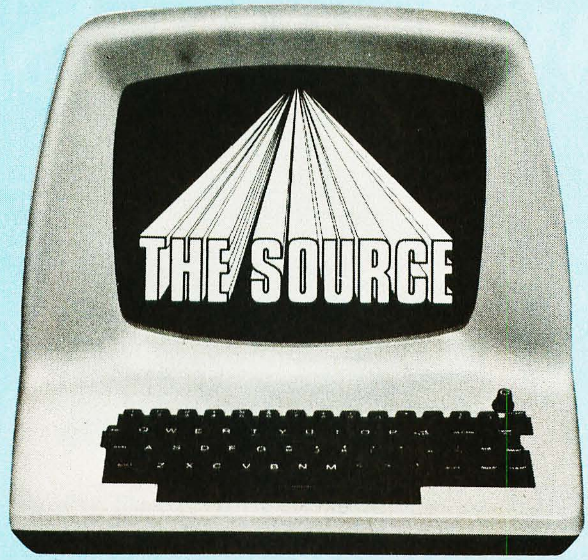
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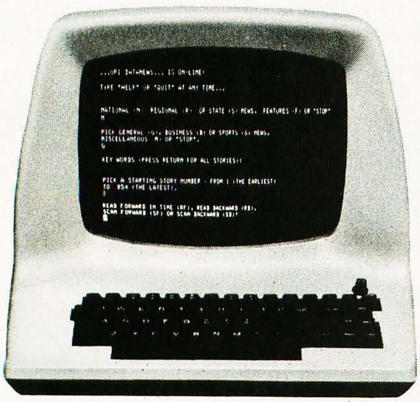


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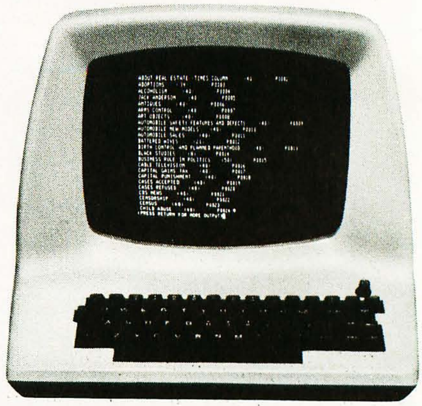
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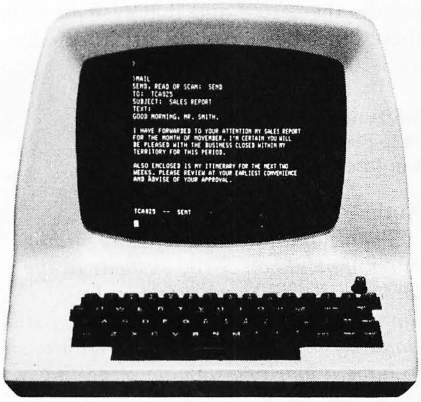
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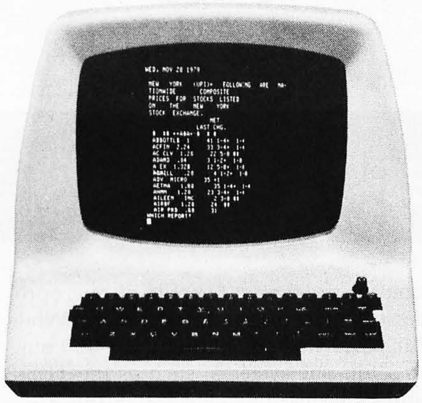
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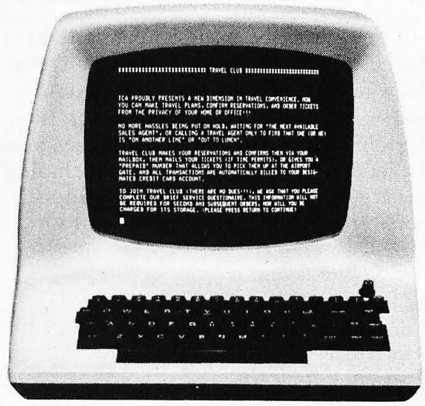
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Letters

8086 Software Needed

I am interested in designing systems based on 8086 processors. Does anyone have some useful systems software to sell? I am particularly interested in file-handling software and operating systems in general. I am interested in purchasing source listings and I am prepared to visit software houses on my next trip to the US.

Martin Healey
Computer Systems Consultant
9 Ennerdale Close
Penylan, Cardiff CF2 5NZ
GREAT BRITAIN

Battle of the Buses

In the October 1979 "BYTE News," page 107, Sol Libes contends, in an item about the S-100 bus, that "those who wish to have a machine capable of getting the maximum benefits of microprocessors must go the S-100 route." While Mr Libes was comparing the S-100 bus to all-in-one systems, such as the TRS-80 and PET, his statement leaves out a number of computer systems with as much capability as S-100 systems, perhaps more in some cases. For example, the SwTPC S/09 and the Ohio Scientific Challenger III Series are two systems that come to mind. The former uses a 6809 processor with the SS-50 bus (see October BYTE, inside front cover), and the latter uses 6800, 6502, and Z80 processors and apparently OSI's own bus (see back cover, same issue). Both of these systems have a 20-bit address bus for large memories. SwTPC and several other companies make SS-50 bus systems using the 6800. Other non-S-100 bus systems include the Heath H8 and H11. Any of these systems, and probably others that I have left out, can be as good for serious personal computer users as any S-100 bus computer. The S-100 bus is *not* the only possible route.

Mr Libes also writes that "the S-100 bus is not processor dependent." This statement is debatable, in spite of the existence of S-100 boards for a number of microprocessors. Several signals on the S-100 bus are generated ONLY by the 8080. Any other processor must be "bent" into generating (or responding to) these 8080-specific signals.

Personal computing could use a truly processor-independent bus. I feel that the S-100 bus will not be totally satisfactory in this role.

The mention of specific products in this letter does not necessarily constitute endorsement of these products. My point is simply that there are other buses besides the S-100, and that systems using these other buses can be just as capable as S-100 systems.

Jim Howell
5472 Playa Del Rey
San Jose CA 95123

Author Libes replies:

Thank you for your letter regarding my comments on S-100 systems in the October BYTE News column. Despite the views expressed in your letter, I still stand by my view that "those who wish to have a machine capable of getting maximum benefits of microprocessors must go the S-100 route." I agree with you that SS-50 and OSI Challenger III systems offer more power than integrated systems such as the TRS-80, Apple and PET. However, they still leave much to be desired compared to S-100. I will explain shortly.

Further, I also stand by my statement that "the S-100 bus is not processor dependent." The fact is that presently there are manufacturers selling six different 8-bit processor boards (8080, 8085, Z80, 6502, 6800 and 6809) and five different 16-bit processor boards (9900, LSI-11, 8086, Z8000 and Pascal Microengine) for S-100 systems. This means that eleven microprocessors have already been interfaced to the S-100. I do not know of any other system with this processor independence. Many of these microprocessors could not even be interfaced to buses such as the SS-50 or OSI without sacrificing performance.

When it comes to maximum power and flexibility the S-100 offers the following advantages over all other systems:

- *More software available. There are several times more languages, operating systems and applications packages for S-100 systems than for any other system.*

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- *There are currently close to two dozen different manufacturers of S-100 mainframes and about fifty manufacturers of over 400 S-100 plug-in boards. This is many times more than for any other system.*
- *There is greater computer power capability with S-100. What other system has direct addressing of up to 16 megabytes of memory (24 address lines) and 64 K input/output ports (16 address lines), up to eleven vectored interrupt lines, up to sixteen masters on the bus (with priority), up to twenty-three plug-in slots on the motherboard, up to 10 MHz clock on the bus, plug-in operator front panel, and more.*
- *The S-100 bus is now standardized by the Institute of Electrical and Electronic Engineers (IEEE) assuring conformance among manufacturers.*

Regarding your reference to the H8 bus, note that Heath has discontinued production of this unit. Besides, it was dedicated exclusively to the 8080 and therefore was destined to an early death. The Heath H11 is essentially the same as and uses the same bus specifications as a Digital Equipment Corp LSI-11. Few other firms support the LSI-11 with products within the price range of the typical hobbyist. The hardware and software facilities, compared to the S-100, are limited and expensive.

Again, thank you for reading my column and I welcome any further comments you wish to make regarding my opinions.

Sol Libes

Pi in the Sky

As I get older, I forget more and more often that the "tricks" I sometimes use may not be common knowledge. I have recently come across several short programs that evaluate π to five or six decimal places. These are good programs, and I salute their authors. I, however, use the shortest of all programs for π and would like to pass it on. It gives an approximate answer that is in error by 27 parts in 100 million. Since this is well within the allowable error of most computers, I use it without hesitation in all computer programming expressions.

Here goes. To enter π accurate to six decimal places, write in its place 1/(113/355). That's all there is to it! The value of that expression is 3.14159292, while π is 3.14159265 . . . .

This little gem was taught to me for use on the slide rule, back during the 1940s. I pulled it out of my memoirs recently when I got my first microcomputer.

Please note that the denominator is easily remembered as the first three odd integers, doubled. The order of their appearance is obvious.

Emory W Sprenkle Jr
POB 542 (53 Allen Rd)
Billerica MA 01821

Keep Telling It Like It Is . . .

Thank you for the November editorial regarding pseudoscience and biorhythms in particular. It was certainly refreshing to have a hobbyist magazine of BYTE's reputation so clearly delineate between harmless biorhythm algorithms for the sake of computing recreation and the unscientific foundations of biorhythmic theory. Too many supposedly educated and intelligent people seem to have fallen into the "computer generated, therefore true . . ." trap you described. Perhaps you have caused some of them to critically examine the unsupportable premises of biorhythmic theory. Now if I could just get the campus radio station to stop broadcasting horoscopes . . .

Thomas Dolash
Assistant Professor of Physics
Physics and Engineering Dept
Vincennes University
Vincennes IN 47591

Good Humor Needed

I have found your magazine to be very educational and of excellent quality. I look forward to getting the new issue each month. However, I have a suggestion that I think might make your magazine even better and would be enjoyed by all your readers. Why not add a "Jokes & Riddles" column and a comic strip or two, and maybe a few "one-framers"? I realize that your magazine tries to present a serious approach, but I think that this addition would be a plus, and a bit of humor would make it more fun for everyone. So how about it?

William P Carlson
Rosewood Cir
North Syracuse NY 13212

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*The problem is finding cartoon and humor generators who also understand the current era in computing. . . .***CH** ■

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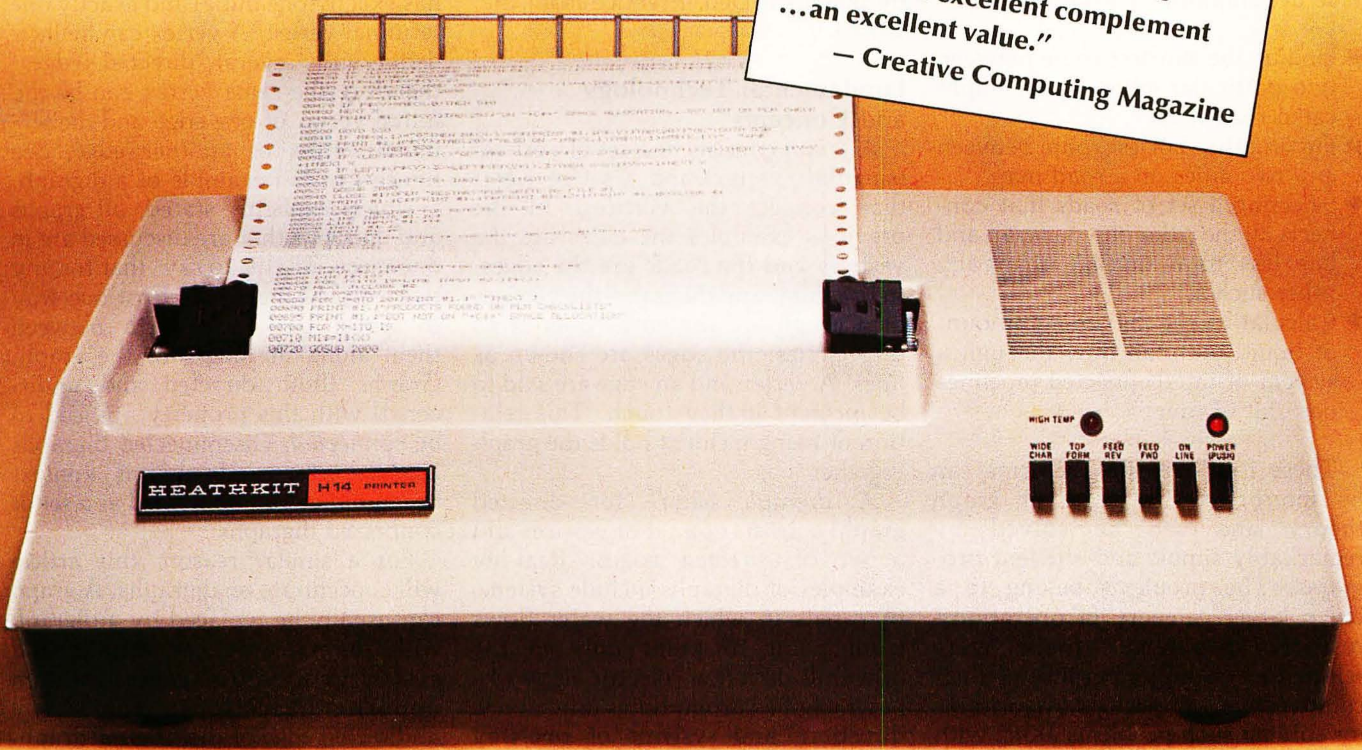
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A First Look at Graph Theory Applications

Michael Ashbrook
Helmut Zinn
Wilhelm Epstein Str 27
6000 Frankfurt am Main 50
WEST GERMANY (BRD)

What do the following problems have in common?

- Finding the shortest route between two particular cities on a complicated road map.
- Finding the shortest route between *any* two cities on a road map.
- Selecting a set of roads that connects all the cities on your map and has less total mileage than any other such set.
- Calculating the maximum amount of liquid that can flow through a system of interconnected pipelines per unit of time.

These four real-life problems can be interpreted in terms of graph theory and can be solved by remarkably simple and efficient programs. The problems belong to a much larger category of operations-research problems; these were selected as examples because of their comparative simplicity. Algorithms for solving such problems along with the necessary background for understanding them will be examined.

While our terminology follows that of Narsingh Deo, our programs are quite different from his. If you become interested in solving more graph-theoretic problems on your own, you will find his book a stimulating introduction. (See *Graph Theory with Applications to Engineering and Computer Science* by Narsingh Deo, Prentice-Hall, Inc, 1974.)

Fundamental Technology and Concepts

A *graph* consists of a set of *vertices* (singular: vertex) and a set of *edges* that connect the vertices. In the previous examples the cities are the vertices and the roads are the edges. In drawings and diagrams the vertices of a graph are shown as dots or as tiny circles; the edges are shown as lines. A vertex and an edge are said to be *incident* if they touch. This relation of being incident holds the graph together.

A *digraph* (short for directed graph) consists of a set of vertices and a set of *directed* edges. Real-life examples of digraphs include systems of canals in which the water flows from point to point only in the downhill direction, electric networks in which the current flows only in one direction, and systems of one-way streets. The vertex from which a directed edge starts is called the *initial vertex* of the edge; that would be the point at the higher end of a canal. The vertex at which a directed edge ends is called the *terminal vertex* of the edge; that would be the point at the lower end of the canal.

Remember that each edge is incident (touches) with exactly two vertices, therefore every directed edge has exactly one initial and exactly one terminal vertex. A vertex can be incident with several directed edges, therefore the same vertex can be the initial vertex of one edge and the terminal vertex of another edge. See figure 1 for an example of a digraph.

Unless explicitly stated, all graphs and digraphs that are discussed are in one piece. That is to say, that for any two vertices there is at least one way to travel back and forth between them along the edges of the graph. Graphs (both directed and undirected) with this property are said to be *connected.* Disconnected digraphs are not discussed in this context because they can be treated as a set of connected digraphs.

For a similar reason, this article will concentrate on digraphs. A graph can usually be replaced by a digraph with the same set of vertices and exactly two directed edges, going in opposite directions, for every undirected edge of the original graph.

There are many ways to represent a digraph in a computer. Each method

About the Authors

Michael Ashbrook became interested in operations research after first studying mathematics. Helmut Zinn became involved with small computers through his work in electromechanical engineering. Both collaborate at the Technische Hochschule in Darmstadt.



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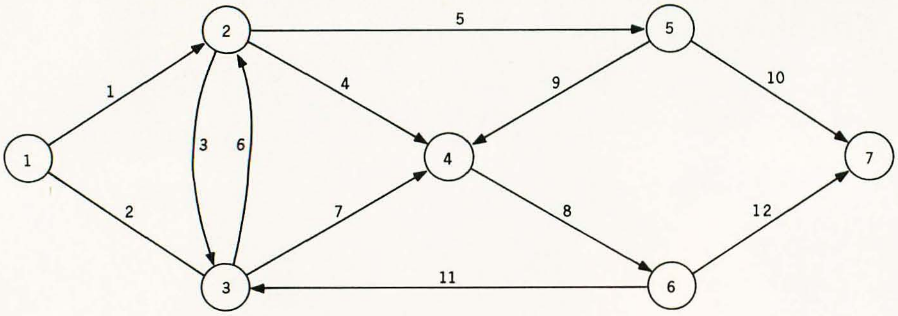


Figure 1: *Example of a digraph (directed graph) that has seven vertices* ***and*** *twelve directed edges.*

has its advantages and its drawbacks; each has its applications. The two basic methods used to encode a digraph will now be discussed.

A Matrix Called DIGRAPH

Consider a digraph containing a certain number of vertices n_v. The n_v vertices of this digraph are represented by the natural numbers from 1 to n_v. The edges of the digraph are represented by the entries of an n_v by n_v matrix called DIGRAPH. If the digraph has a directed edge from the vertex i to the vertex j, then the entry DIGRAPH(i, j) of matrix DIGRAPH that is in the i-th row and the j-th column has a nonzero value, DIGRAPH(i, j)$\neq$0. If there is no edge from vertex i to vertex j, the matrix entry DIGRAPH(i, j) is 0.

The matrix DIGRAPH can be used to store additional information about the digraph. If DIGRAPH is the mathematical model of a road map, the nonzero entries can be used to represent the distance from city i to city j. If you need to store no more data about an edge than the two vertices i, j which it connects, then the

A directed graph (digraph) consists of a set of vertices and a set of directed edges.

presence of the edge in the digraph is usually indicated by setting DIGRAPH(i, j)=1.

The matrix DIGRAPH is best suited for small-scale applications which involve no more than roughly fifty vertices. A digraph with n_v vertices can be stored as a matrix that requires $(n_v)^2$ storage locations.

Disadvantages of Matrix Storage

In large-scale applications involving several hundred vertices, the matrix DIGRAPH often becomes *sparse* (or sparsely populated). The proportion of entries that are equal to zero increases. This happens because the real-life structures that are being stored as digraphs have relatively few edges compared to the number of edges which they could have.

Every town in the United States could be connected with all of the other towns by a direct road. As a practical matter, however, any given town is linked directly to only a few neighboring communities. Therefore, the DIGRAPH matrix of the total road system consists almost entirely of zeroes that mean nothing but the absence of a direct road between most combinations of two given towns. This matrix is very large and cannot be stored efficiently.

Increasing Storage Efficiency

In order to solve large-scale problems using a limited amount of storage space, a more efficient way of storing digraphs is necessary. Space should not be wasted on 0s that represent nonexistent edges.

As before, the n_v vertices of the digraph are represented by the numbers 1 to n_v. The edges are listed as pairs of numbers; the edge from vertex i to vertex j is shown as the pair (i, j).

Suppose the digraph has a certain number of edges, n_e, then these edges can be expressed as an n_e-by-2 array called EDGE. Each row (i, j) of the EDGE array specifies one edge; the first entry i stands for the edge's initial vertex i, and the second entry j stands for the terminal vertex j of the

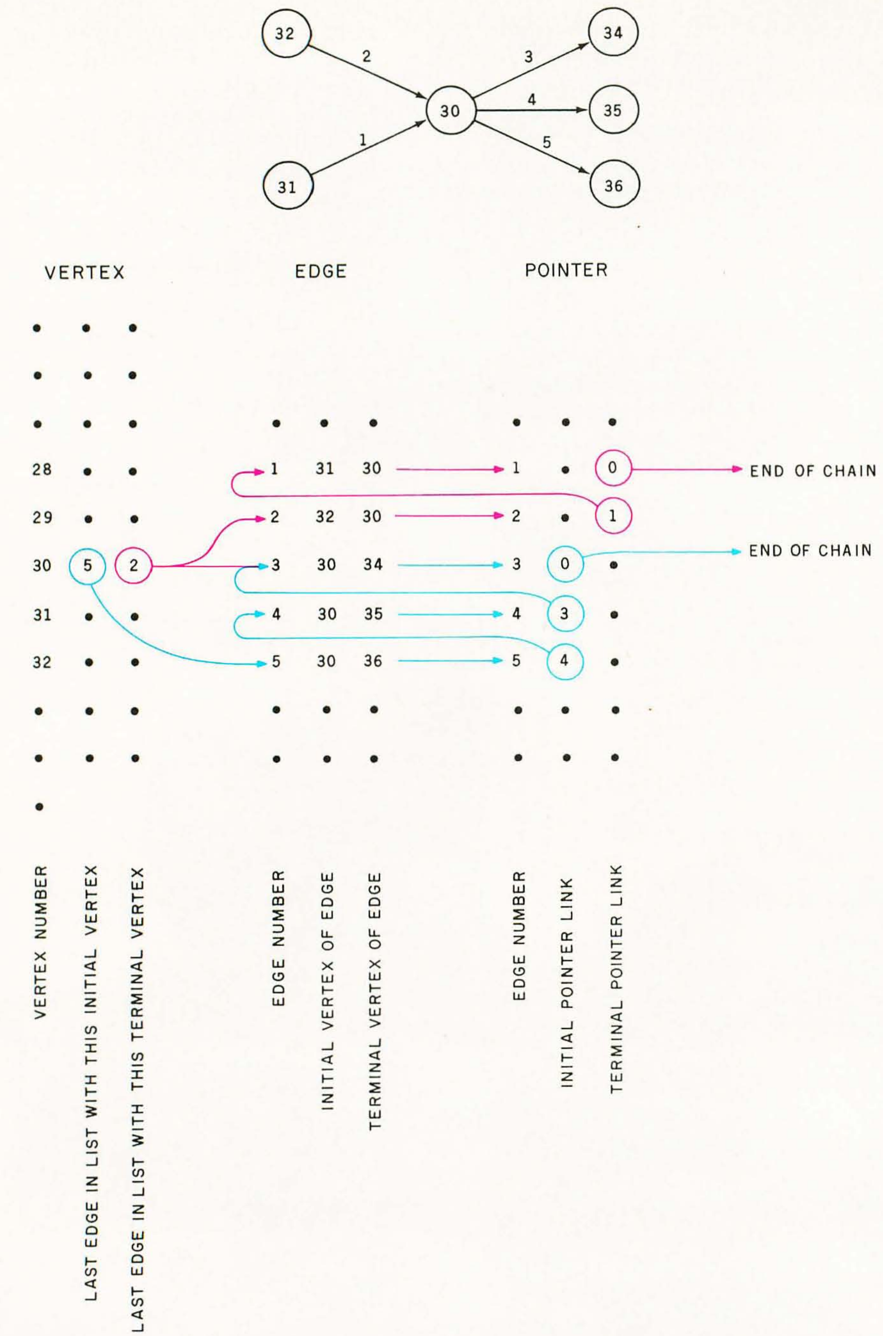


Figure 2: *Portion of a digraph as represented by the list-oriented data structure. The arrows connecting the entries in the three lists (2-by-2 arrays) show the logical connections in storage that represent the structure of the digraph. The arrows can be read as "points to."*

In the list EDGE, after the identification number of the edge, two numbers that specify the initial and terminal vertices of that edge are found. For example, edge 3 has initial vertex 30 and terminal vertex 34.

In the list POINTER, each edge number has associated with it two other numbers that refer to positions of edges in the list EDGE (not in the digraph itself). The initial pointer of an edge refers to the last edge preceding the current edge that has the same initial vertex as the current edge. For example, the fourth entry in the POINTER list shown here points to the entry 3 in the EDGE list, showing that edge 4 has the same initial vertex as edge 3. The terminal pointer of an edge refers to the last edge preceding the current edge that has the same terminal vertex as the current edge.

In the list VERTEX, for each vertex in the digraph, there is an entry that tells the number of the last row of EDGE in which the current vertex appears as the initial vertex. There is also an entry that tells the number of the last row in the EDGE list in which the current vertex appears as a terminal vertex. For example, observe that the last edge with initial vertex 30 is edge 5; the last edge in EDGE with terminal vertex 30 is edge 2.

edge. If there is more information to be stored concerning the edges, then columns can be added to EDGE.

For the sparse digraphs that are being considered, the amount of storage space needed for EDGE is kn_v rather than n_v^2; where k is the average number of edges per vertex in a given digraph.

The price for this significant saving in space is an increase in access time. To find all the edges incident with a vertex *i* in DIGRAPH, simply scan the *i*-th row and the *i*-th column of DIGRAPH. To find all the edges incident with vertex *i* in EDGE, scanning the entire list is necessary. Since all of the programs rely heavily on finding the edges that are incident with a given vertex, it pays to trade a little storage space for a reduction in access time.

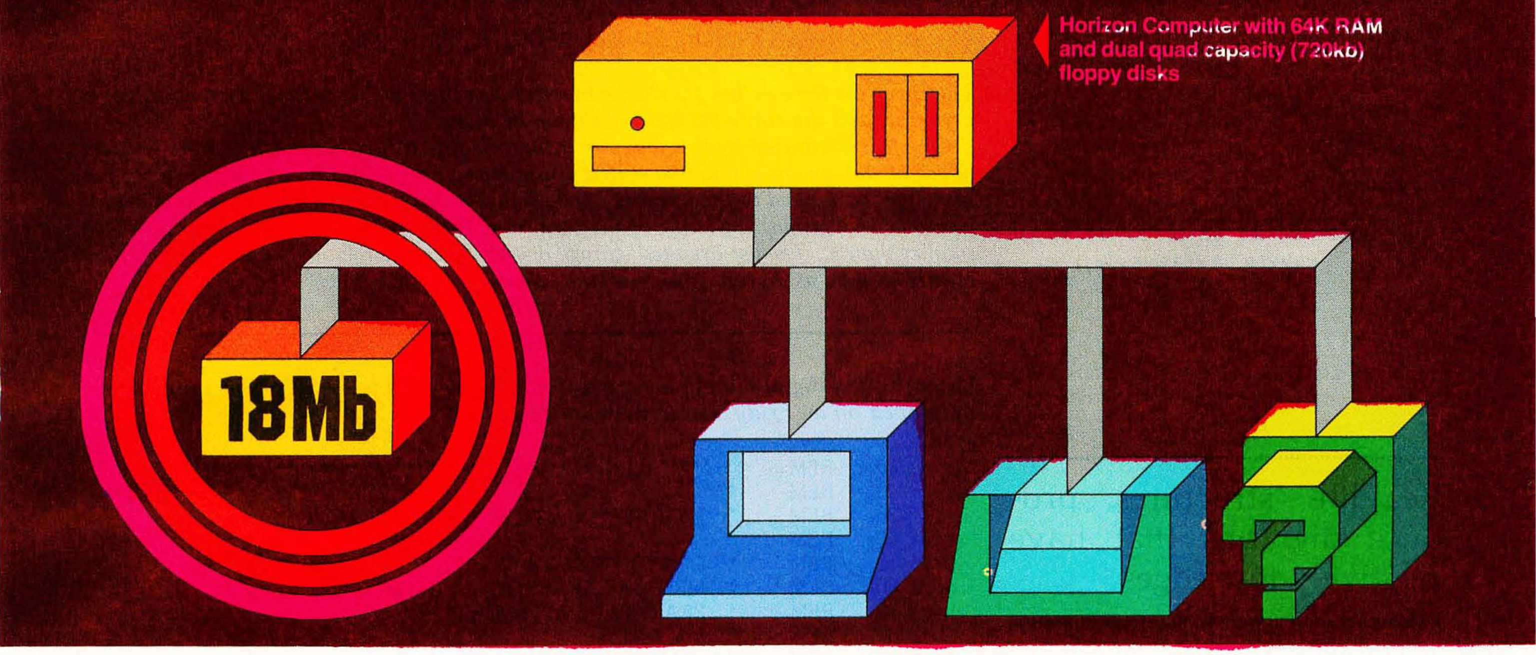
To cut down on the access time, add a column of initial pointers and a column of terminal pointers to EDGE. You can spare yourself needless confusion if you always remember that these pointers refer to the positions of edges in the *list* EDGE and not in the digraph itself.

The *initial pointer* of a particular edge (*i, j*) refers to the last edge preceding the current edge (*i, j*) in EDGE that has the same initial vertex *i* as (*i, j*). If (*i, j*) is the first edge in EDGE that has the initial vertex *i*, then the initial pointer of (*i, j*) has the value zero.

The *terminal pointer* refers to the last edge preceding (*i, j*) in EDGE which has the same terminal vertex *j* as (*i, j*). If (*i, j*) is the first edge in EDGE with the terminal vertex *j*, then its terminal pointer has the value zero.

In order to reduce the access time further, establish a list called VERTEX in the form of a 2-by-n_v array. The *i*-th row of VERTEX stands for the *i*-th vertex of the digraph. The value of VERTEX(*i*, 1) is the number of the last row of EDGE in which *i* appears as the initial vertex. The value of VERTEX(*i*, 2) is the number of the last row in EDGE in which *i* appears as a terminal vertex.

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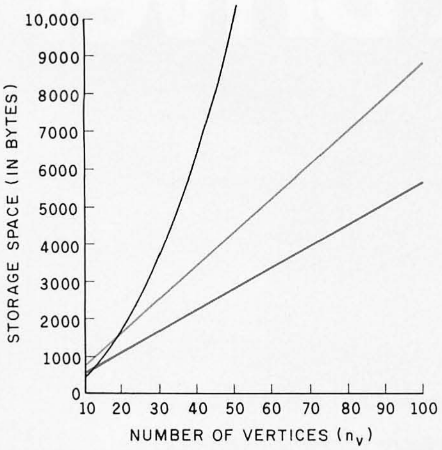


Figure 3: *Graph showing storage space requirements (st) of a digraph plotted as a function $st(n_v)$ of the number of vertices (n_v) in a given digraph. It should be assumed that four bytes are required to store a decimal number.*

The upper curve (black) shows the function $st(n_v)$ when you use the method of storing your digraph representation in the matrix DIGRAPH.

Storage requirements of the list-oriented storage scheme vary according to the number of edges (n_e). The equation is $st(n_v, n_e) = 2n_v + 4n_e$. If the digraph has some constant k times as many edges as it has vertices (represented by the equation $n_e = kn_v$), then the equation of storage space becomes

$$st(n_v) = 2n_v + 4kn_v = (4k + 2)n_v$$

The curve for the case k=3 is shown in red (when there are three times as many edges as vertices), and the curve for k=5 is shown in blue.

One fact illustrated by this diagram is that the list-storage approach is more efficient in use of storage space than the matrix approach so long as the digraph being stored has few edges compared to the number of edges that it could have (a sparsely populated [or just sparse] digraph). In terms of the equations here, sparseness means that k is much smaller than n_v. The list-oriented storage method becomes relatively more efficient than matrix storage as digraphs become more sparse.

Real-life structures produce digraphs that have relatively few edges.

The list-oriented digraph representation is illustrated in figure 2.

Searching the Lists

Suppose you want to find those edges that have *i* as their initial vertex. Look at VERTEX(*i*, 1); if its value is zero, there are no such edges in the digraph. If its value is some nonzero value *x*, the first such edge is found in the *x*-th row of EDGE. If the value of the edge's initial pointer, PTR(*x*, 1), is zero, there are no more such edges in the digraph. (POINTER is a reserved word in our BASIC interpreter, so we have to use the abbreviation PTR.) If PTR(*x*, 1) equals some nonzero value *y*, the next such edge is found in the *y*-th row of EDGE and the new pointer is found in PTR(*y*, 1).

Continue to follow the pointers from edge to edge until a pointer with the value zero is found, which tells you that you have now found all the edges that have *i* as their initial vertex. If you substitute the value 2 wherever 1 occurs in the preceding paragraph, then there is an adequate explanation of the systematic search for all edges that have *i* as their terminal vertex.

The same scheme that has been

Listing 1: *The digraph input and concatenation program in BASIC. This program was developed on an Exidy Sorcerer computer system.*

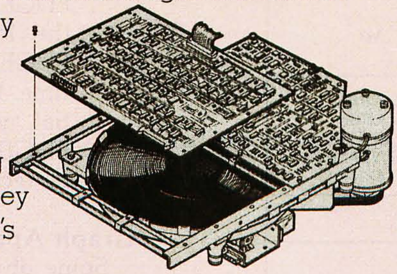
```
10   REM    ********************************************
20   REM    *                                          *
30   REM    *  DIGRAPH INPUT AND CONCATENATION         *
40   REM    *                                          *
50   REM    *  COPYRIGHT 79/4 BY                       *
60   REM    *  MICHAEL ASHBROOK & HELMUT ZINN          *
70   REM    *  FRANKFURT AM MAIN                       *
80   REM    *                                          *
90   REM    ********************************************
100  REM READ AND LINK EDGE LIST
110  INPUT "NUMBER OF VERTICES"; NV
120  INPUT "NUMBER OF EDGES    "; NE
130  DIM VERTEX(NV, 2)
140  REM VERTEX(V, 1) = EDGE WITH V AS INITIAL VERTEX
150  REM VERTEX(V, 2) = EDGE WITH V AS TERMINAL VERTEX
160  DIM EDGE(NE, 2), PTR(NE, 2)
170  REM EDGE(E, 1) = INITIAL VERTEX OF EDGE E
180  REM EDGE(E, 2) = TERMINAL VERTEX OF EDGE E
190  REM PTR(E, 1) = NEXT EDGE WITH THE SAME INITIAL VERTEX
200  REM PTR(E, 2) = NEXT EDGE WITH THE SAME TERMINAL VERTEX
210  FOR E=1 TO NE
220  PRINT E; "EDGE (INITIAL VERTEX, TERMINAL VERTEX) ";
230  INPUT EDGE(E, 1), EDGE(E, 2)
240  NEXT E
250  REM SETTING UP THE POINTERS
260  REM L=1 IMPLIES INITIAL POINTER OR VERTEX
270  REM L=2 IMPLIES TERMINAL POINTER OR VERTEX
280  FOR L=1 TO 2
290  FOR E=1 TO NE
300  V=EDGE(E, L)
310  IF VERTEX(V, L)=0 THEN PTR(E, L)=0: GOTO 330
320  PTR(E, L)=VERTEX(V, L)
330  VERTEX(V, L)=E
340  NEXT E
350  NEXT L
360  PRINT
370  PRINT " VERTEX LIST";
380  PRINT TAB(20); "EDGE LIST";
390  PRINT TAB(40); "POINTER LIST"
400  N=NV: IF NV<NE THEN N=NE
410  FOR I=1 TO N
420  IF I>NV THEN GOTO 440
430  PRINT I;VERTEX(I, 1);VERTEX(I, 2);
440  IF I>NE THEN GOTO 470
450  PRINT TAB(20);I;EDGE(I, 1);EDGE(I, 2);
460  PRINT TAB(40);I;PTR(I, 1);PRT(I, 2);
470  PRINT
480  NEXT I
490  END
```



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Listing 2: *A sample execution of the program of listing 1 using data from figure 1. An interpretation of the output is given in figure 2.*

```
RUN
NUMBER OF VERTICES? 7
NUMBER OF EDGES   ? 12
1  EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 1,2
2  EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 1,3
3  EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 2,3
4  EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 2,4
5  EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 2,5
6  EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 3,2
7  EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 3,4
8  EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 4,6
9  EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 5,4
10 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 5,7
11 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 6,3
12 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 6,7


VERTEX LIST              EDGE LIST              POINTER LIST
  1  2  0                  1  1  2                1  0  0
  2  5  6                  2  1  3                2  1  0
  3  7 11                  3  2  3                3  0  2
  4  8  9                  4  2  4                4  3  0
  5 10  5                  5  2  5                5  4  0
  6 12  8                  6  3  2                6  0  1
  7  0 12                  7  3  4                7  6  4
                           8  4  6                8  0  0
                           9  5  4                9  0  7
                          10  5  7               10  9  0
                          11  6  3               11  0  3
                          12  6  7               12 11 10

READY
```

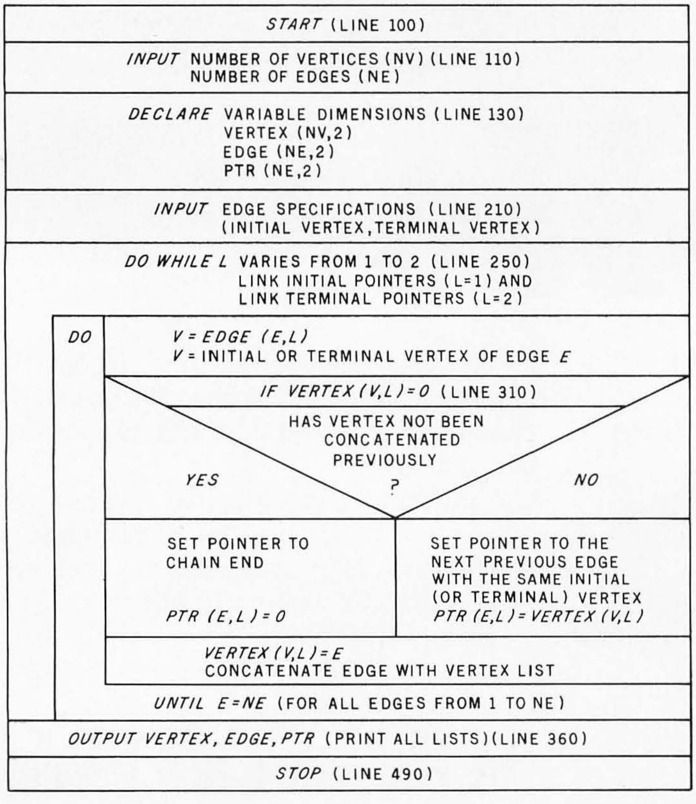


Figure 4: *A Nassi-Schneiderman chart showing the algorithm used by the BASIC program of listing 1. Nassi-Schneiderman charts are a system of stylized flowcharts that are designed for use with structured programming techniques. The chart is read from top to bottom. Line numbers refer to lines in the BASIC program in listing 1.*

introduced to store digraphs can be used for storing *undirected* graphs by ignoring the distinction between initial and terminal vertices and pointers. In the case of undirected graphs, a single pointer would serve as well as two pointers and occupy less storage space. If you are enterprising, you can work out the details of this variation and write the appropriate program yourself. Figure 3 compares storage requirements.

Generating Lists Under Program Control

Have you wondered why the lists have been searched from bottom to top and why the pointers are linked backwards? By doing so, you can simplify the task of generating the pointer lists.

The Nassi-Schneiderman chart given in figure 4 shows the logic followed by the BASIC program of listing 1. Here is some additional explanation. Numerals refer to line numbers in listing 1.

300 Assume that you are linking the initial pointers (with L=1). The initial vertex of edge E is stored in V.

310 If the vertex number V has not been recorded as an initial vertex up to now, you have found the end of its chain of initial pointers. Skip line 320 because there is no previous pointer to link up with.

320 If V has been previously recorded as an initial vertex, get the location of its earlier occurrence in EDGE from VERTEX and set the initial pointer PTR(E, 1) of edge E to point to this location.

330 Record the location E of V in list EDGE in VERTEX(V, L). This is the lowest location of V in EDGE that is known at this time. If V occurs again as an initial vertex further down in EDGE, this lower location will be recorded.

Graph Applications

Some obvious examples of graphs and digraphs that occur in the real world have been mentioned: communication and transportation networks. There are more abstract systems that also have an undirected or directed graph structure.

Complicated projects consisting of



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thousands of interdependent *tasks* are often planned with the aid of graph-theoretic methods. The tasks can be considered as the vertices of a digraph; their interdependencies can be expressed as directed edges.

This approach allows managers to visualize the problems about which they must make decisions, and gives the managers the opportunity to delegate routine work to the computer. The maximum and minimum times for project completion and the effects of delays upon parts of the project or upon the whole project can be calculated by simple software routines.

The first large-scale project to which these methods were successfully applied was the development of the Polaris missile system. Today, use of *project networks* is a standard management technique.

If you are interested in applying graph theory to the social sciences, you should read *Structured Models: An Introduction to the Theory of Directed Graphs* by Harary, Norman, and Cartwright.

Closing Observation

This article cannot end without observing that almost all users of computers are intimately familiar with one form of directed graph, the flowchart. ■

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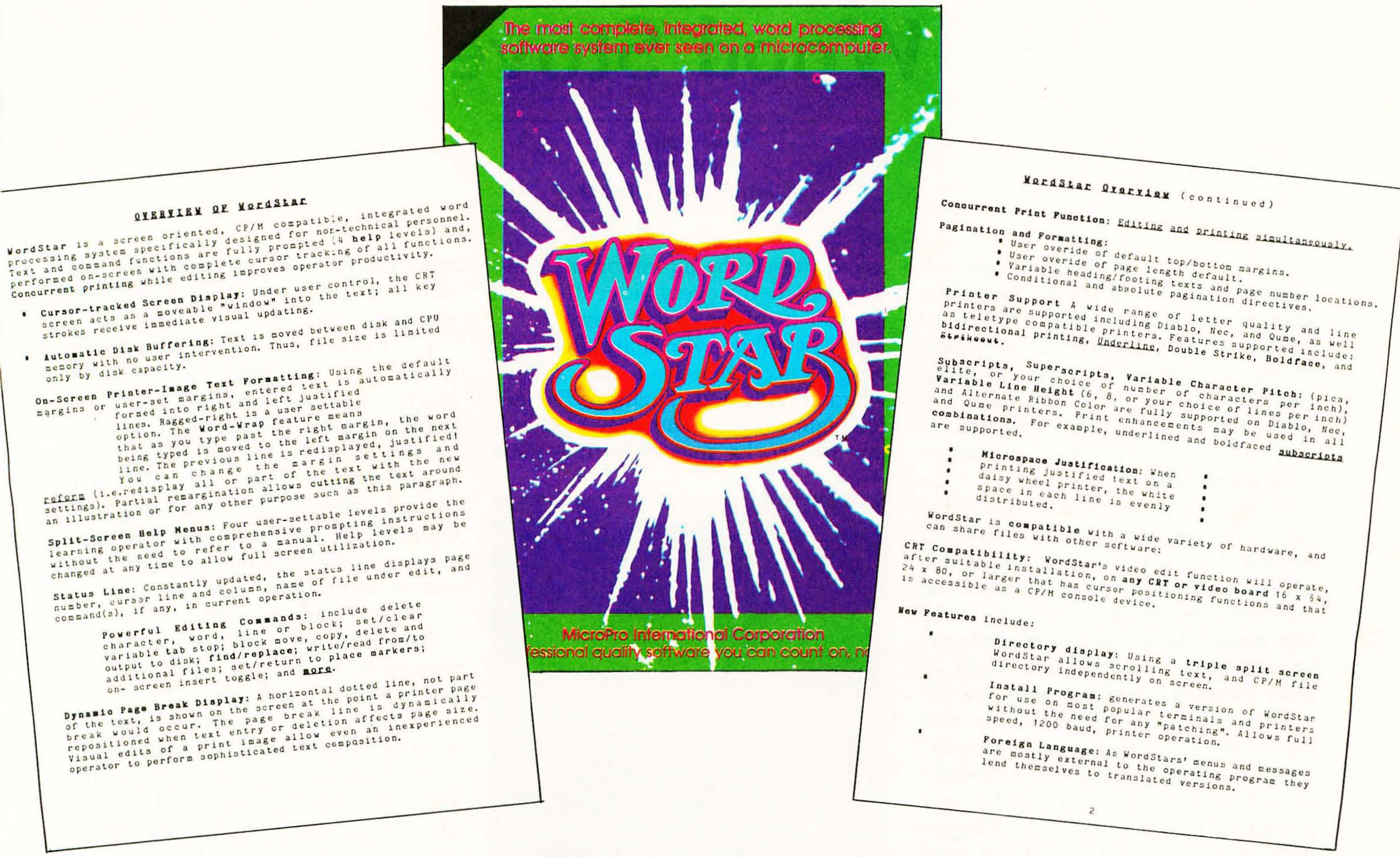
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A Computer-Controlled Wood Stove

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"Come inside, Roger, and get out of the cold." I held my kitchen door ajar as he crossed the front yard towards me. Great clouds of leaves blown by the cold wind furiously encircled him. The landscape was stark and gray, and all weather indicators pointed toward an impending snowstorm.

Roger, a local electrician, had come by to discuss some electrical work I needed done on a new garage I was building. As he stepped through the doorway he remarked, "Sure looks like snow. Have you got enough gas for your Jeep in case you need to plow yourself out of this wilderness?"

Roger's remark reminded me that the terms "picturesque" and "remote" are often synonymous when describing a home in Connecticut. The only place I had been able to buy a house with more than half an acre of land was 25 miles from civilization. And while Roger's controlled, old Yankee humor prevented him from laughing out loud as he spoke, the thought of me, basically a kid from the city, independently plowing my 300 yards of driveway seemed to produce a slow-forming look of amusement.

The Jeep he was referring to was about 20 years old and was used only for plowing. I rather enjoyed the straightfoward task of rearranging snow with it. A certain spirit of excitement came over me each time I stepped into the driver's seat and asked myself the all-important question posed by every adventurer: "I wonder if this heap will start?"

My neighbor, who shares the chore of plowing, thought I was a sissy when I finally added lights to the Jeep for night driving. Somehow, not seeing the rocks makes hitting them more fun for him. I never did ask him how he had broken the driveshaft the previous year.



Photo 1: *The Hydrostove is installed in the corner of the Circuit Cellar. Take note of the two copper pipes coming out the rear of the stove into the wall. The pipes, which are buried behind the wall and above the ceiling, go to the furnace, which is 35 feet away.*

I continued my masochistic thoughts of the Jeep. "It should be okay," I said, "but frankly, if it breaks down, I think I'll just hibernate in the cellar for the winter."

Roger still had not taken his coat off as he added, "You might expect to enjoy such an arrangement, but I think you will find that you need outside services more than you think."

"Give me an example."

Roger uncomfortably shrugged his shoulders. Something other than the conversation was bothering him.

"Oil is a good example. You heat with oil, right? How do you propose to fill your oil tank if the truck can't get down the driveway? I'll bet this glass barn you have here almost requires a direct pipeline to the refinery."

I did not exactly relish having my contemporary home called a glass barn but there was some merit to his statement. I retorted, "Who needs..."

Roger interrupted me in *mid-statement*. "Speaking of heat... what are you running here, a sauna?"

"Take your coat off, Roger. Maybe then you won't be so hot. I'm not so sure you even need both the wool shirt and sweater you have on."

Tossing his coat across to the nearest chair and tugging on his sweater, he continued. "Whenever I

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Photo 2: *Logs up to 24 inches in length are placed in a grate which consists of water-filled tubes.*

visit anyone during the winter I presume their house is at 60 degrees like mine. It must be 12 degrees outside, and..." he walked over to the thermostat, "according to this it's 75 degrees in here!"

"I don't usually have it this warm, I was just testing the heating system now that it's computer-controlled."

"What's there to control? Turn the oil burner on longer and it gets hotter."

"Who said anything about an oil burner?"

"Electric heat is even worse!" he quickly added.

"We have oil heat... but it hasn't been on for two days. All I have now is one wood stove."

Roger's momentary blank stare and open mouth were instantly replaced with a look of disbelief. Standing there by the thermostat he quickly scanned the room. With extreme skepticism he replied, "What are you handing me? A twelve-hundred-square-foot room, twelve-foot ceiling, three hundred square feet of glass and seventy-five degrees? I don't see any stove!" Roger walked over to a hot-air duct near one of the windows, stooping down and holding his open palm over the opening he exclaimed, "Wood stove, phooie! There's hot air coming out of this duct. You have the oil burner on!"

"No, Roger. I have a wood stove down in the Circuit Cellar that is plumbed directly into the central heating system."

"A wood stove? In a hot-air heating system?"

"Well actually, Roger, my heating system is both hot water and hot air, and the wood stove heats water. It's called a hydronic wood stove."

"What the heck is a hydronic wood stove?"

Roger was definitely at a loss for words. I put my hand on his shoulder and said, "Think of it as Yankee ingenuity. Come on downstairs and I'll explain how it works."



Photo 3: *In operation, the heat from the fire warms the water in the tubes. This is a relatively small fire. The fire box is usually filled.*

A Hydronic Wood Stove

A hydronic wood stove is just what the name implies. It is a wood stove that heats water. The particular wood stove that I have is trade-named Hydrostove and it is made by Hydro-Heat Division, Ridgeway Steel, POB 382, Ridgeway PA 15853. Photo 1 shows it installed in the corner of the Circuit Cellar.

The Hydrostove looks like an ordinary wood stove. It is constructed of cast iron and weighs about 400 pounds. The difference between it and a regular wood stove is in the method of heat removal from the burning wood and the ability to channel the energy output into the central heating system.

A regular wood stove produces only radiant energy and is generally a one-room heater unless fans or convection registers are employed to spread the heat around. The surface temperature of such stoves can approach the temperature of the burning wood itself, and great care must be taken to keep combustible material more than 4 feet away.

Typical wood-stove operation is to put in a full load of wood, get it good and hot (warming up the room to around 75° F), and then close the dampers to reduce the heat output. This is the only way to keep the room from becoming unbearably hot. An unfortunate byproduct of this process is that a slow, smoldering fire creates creosote buildup in the chimney. Since only the area directly around the stove is heated, it is likely that an adjacent room will be terribly cold unless fans are used to blow the heat around.

The Hydrostove looks like a regular wood stove, but it operates quite differently. Rather than a solid cast-iron grate, the hydronic stove's firebox is a network of water-filled pipes. These pipes completely encircle the fire, with the burning wood being placed directly on the pipes. Photos 2 and 3 demonstrate this. The inlet and outlet of this water jacket are accessible through two pipe fittings on the rear of the stove. (Since I knew that I wanted a hydronic stove when I built the Circuit Cellar, I had the pipes installed behind the brick wall and

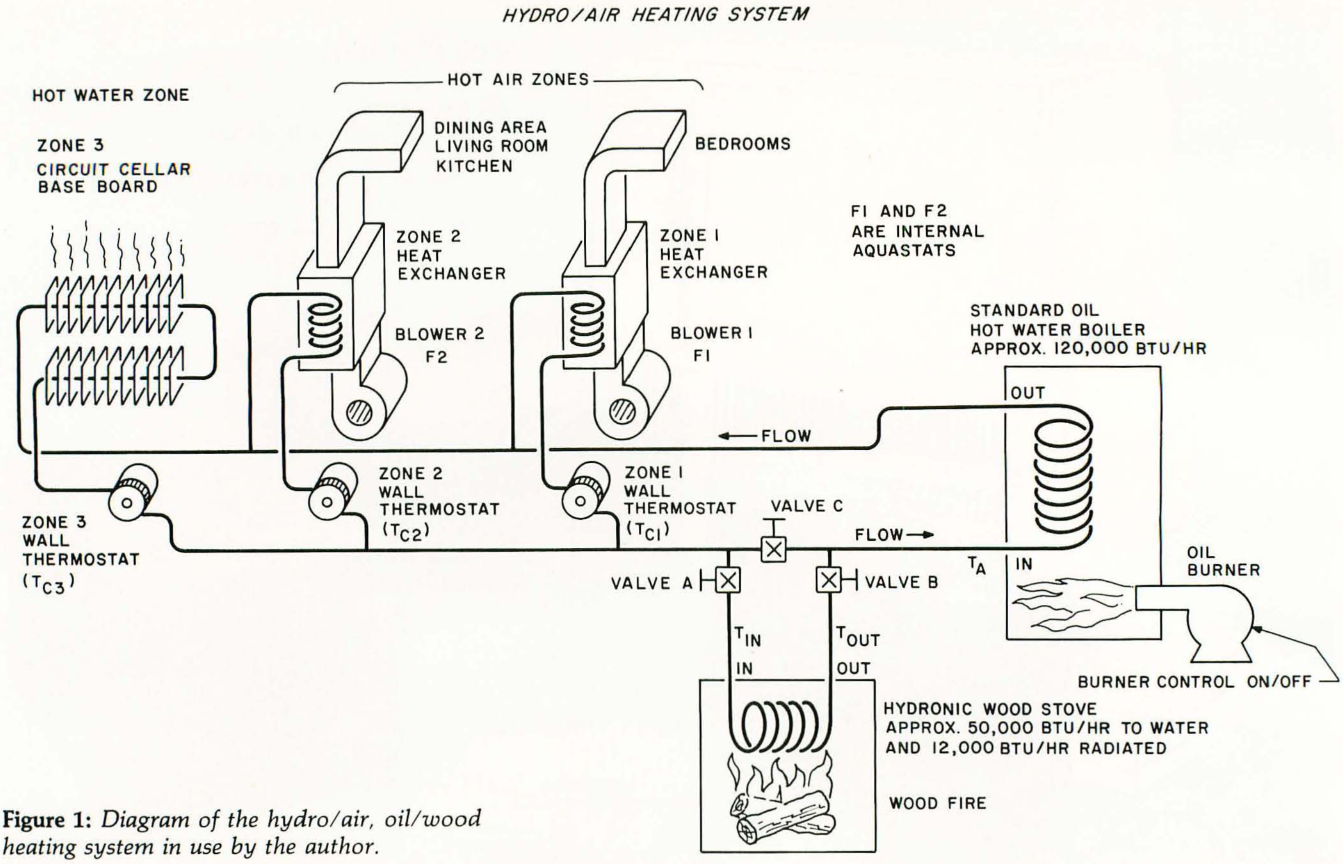


Figure 1: *Diagram of the hydro/air, oil/wood heating system in use by the author.*

through the ceiling. The oil burner is about 35 feet from the Hydrostove.) When a fire is started in the stove, the heat is extracted through the water rather than being radiated directly into the room.

With dry, hard wood, the stove generates about 62,000 BTU per hour (with an additional 12,000 BTU per hour going up the chimney) and is quoted by the manufacturer to be about 85% efficient. I cannot say at this time exactly how much of this is transferred to the water as opposed to how much is radiated. I can only state my experience: with the stove burning at full capacity for 6 hours, the brick wall 1 foot from the stove is only warm to the touch, and wood can be piled next to the stove (about 2 inches away) with no possibility of ignition. For this same 6-hour period, the Circuit Cellar temperature will never exceed 75° F unless a higher temperature is set on the central heating system thermostat. You would definitely know that it is a hot stove, but anyone inspecting the raging fire inside is usually quite surprised how little heat is felt in comparison to a regular wood stove.

A New England Experiment—First, the Basics

The heating system shown in figure 1 is commonly called a hydro/air system. It consists of an oil hot-water boiler and hot-air heat distribution. The oil burner heats water, which in turn circulates through a hot-water heat exchanger. A fan blows over the heat exchanger coils and circulates the hot air through the ducts to each room. Such a system combines the even-temperature, residual-heating benefits of a hot-water circulator with the pleasant, humidified, filtered warmth of a hot-air system. A third zone of baseboard heat was added when the Circuit Cellar was built.

Perhaps the best way to start is to explain how an oil-fired hot-water heating system works. Neglect for a moment zones 1 and 2 and the

Note: The heating system in this article is installed in my home and was built to my specifications. I do not intend this as a general construction article, but rather a documented discussion of the elements of the system with emphasis on the controls involved. I must point out that while this article specifically describes a computer-controlled hydro heating system, general use of a Hydrostove does not require the sophisticated control I have outlined. It is only the unique combination of machinery and an empirically determined operating algorithm that suggests ease of operation through computerization. In truth, the computer's primary value is in the addition of a significant measure of safety rather than the convenience implied. Through its attachment as a supervisory controller, the computer can more accurately maintain safe operating temperatures and dump excess heat in an overtemp condition. As of the time of this writing, two cords of wood have been burned in the stove testing this complete system and the result has been safe, satisfying, and reliable operation.

Hydrostove in figure 1. Think of it strictly as the oil burner connected to one circulator pump and the zone 3 baseboard. This is essentially what many homes have. There may be multiple rooms, but only one circulation loop.

Most people think that the thermostat on the wall turns the oil burner on. Actually, this thermostat only controls the on/off operation of the circulator pump; it generally has no direct connection to the burner itself. Operation of the boiler depends upon the temperature of the water flowing into the heating coil section and the temperature setting T_A of the *aquastat* (water conduit thermostat). Water flows from the hot-water boiler to the baseboard and is drawn back through the circulator pump to the boiler again. If the temperature of this water is greater than the aquastat setting, the burner stays off. If however, the temperature is below T_A, the burner turns on, adding heat until the water in the loop reaches T_A. Usually T_A has a wide hysteresis; the high and low limit of variation is separated by about 20° F. For most boilers the low setting is 160° F, and the high is 180° F. The hysteresis reduces the frequency of oil burner starts.

To get heat in a room, you turn up the wall thermostat, which starts the pump. As the water moves through the baseboard, it loses heat to the room. The water is then reheated by the oil burner.

Now, consider the addition of the Hydrostove as shown in figure 1. Any water circulating through zone 3 will necessarily pass through the coils of the stove if valves A and B are opened and C is closed. This circulation in itself does nothing to the operation of the heating system. If, however, you build a fire in the Hydrostove as in photo 3, heat is added to the water returning from the baseboard and flowing into the boiler. If the fire is large enough, the temperature of the water flowing out of the Hydrostove is greater than T_A, the oil burner never turns on, and the house will effectively be heated by the Hydrostove.

There are a few other considerations. Unlike the oil burner which can be selectively turned on when heat is needed, once the wood stove is on, it runs for quite a while and the heat must be *continuously* removed; otherwise, the water in the pipes will turn to steam. Pressure-relief valves will keep the system from exploding, but who wants a steam bath in their living room? In a single-zone system, the circulator pump must remain on until the fire is out. In a gravity-feed system, the pump must stay on until the fire is lowered to the point where the water stays below the boiling point and can effectively be radiated by the heating loop.

Consider the Hydrostove as a continuous source of heat. If the Hydrostove is cranked up to produce 40,000 BTU per hour, then 40,000 BTU per hour must somehow be removed. The task of heat dumping is much easier on a multi-zone system. Take for example, three zones with capacities of 40,000 BTU, 30,000 BTU, and 20,000 BTU, respectively. Whether or not a room thermostat is calling for heat, you must turn on either the pump for zone 1, or the pumps for both zones 2 and 3. Consider the case when zones 2 and 3 are used as heat dumps. If the zone 1 thermostat were to trip suddenly, the control system would have to make a choice. It could add zone 1 to the pool and share 40,000 BTU among three zones or immediately drop zones 2 and 3 off the line and send everything to zone 1 until it reaches its thermostat setting again. While the previous choice can easily be made, load sharing is an interesting consideration. It is much easier to switch zones on and off while performing load sharing than to try to directly control the heat output of the wood fire to any degree.

An additional complication occurs when using heat exchangers. Heat exchangers cannot effectively transfer heat unless the blower is on. The fans in these units are thermostatically controlled. When the water flowing through the exchanger reaches a set temperature, the fan turns on, extracting heat. There is considerable delay and overshooting in the operation of these units. While the *average* hourly heat transfer of a heat exchanger might be 40,000 BTU, it may be 10,000 BTU with the blower off and 50,000 BTU with it on. In a quick heat-dump situation, it is sometimes necessary to override the blower thermostat and force the





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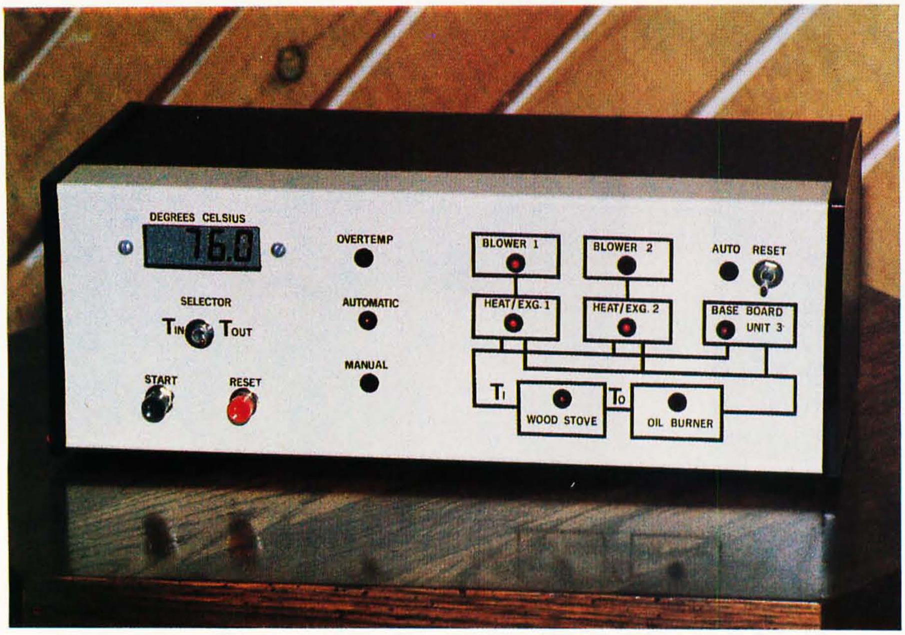


Photo 4: *The computer I/O interface for the heating control system is attractively housed. It includes a display of either the input or output temperature of the Hydrostove and a real-time status display of the circulators and blowers.*

blower on to maintain stable conditions throughout the rest of the system.

Using a Hydrostove

How much you benefit from the addition of a hydronic wood stove depends quite heavily on the rest of your heating system. Above all, it must be capable of taking the full heat output of the wood fire. This can be 62,000 BTU per hour. Since my oil burner is rated at 120,000 BTU per hour, and I had added the third zone of baseboard to the Circuit Cellar, I concluded that the connection would be quite safe.

My usual method of manual operation is to use the stove only on very cold days and to build as large a fire as possible. It is initially started with both dampers open, but once the fire is going strong the flue damper is closed to reduce the amount of heat going up the chimney. At the time the fire is started, the zone 1 circulator pump is turned on continuously with a switch, overriding the motor-start relay. This keeps some water flowing through the stove at all times. Zones 2 and 3 are normally left in their "heat on demand" thermostat-controlled mode. If the Circuit Cellar cooled down and its circulator pump kicked in, it would be drawing heat from the stove along with zone 1.

Our house is large, but given my method of use, no single heating zone can sustain the full output of the Hydrostove for long periods of time. Generally, the water temperature will be between 75° and 90° C. To maintain a 20° to 22° C (68° to 72° F) temperature through the house on a very cold day, I have to keep the fire box continually filled. This means filling the stove with wood every 3 to 4 hours. (Before you choke and compare it to 12 hours for a regular airtight stove, remember that I am talking about heating a whole house). After a few hours of use, even in this large house, the temperature in the rooms in zones 2 and 3 will reach the wall-thermostat set points, no longer continuously demanding heat from the stove. This leaves all the heat going to zone 1.

Soon, the temperature of the water coming out of the wood stove starts to climb above the safe high limit of 88° C (measured 35 feet away at the furnace). When the indicator hits around 98° C, a loud noise can be heard in the pipes because the higher temperature water nearest the hot coals within the stove is turning to steam. Unless you want the safety valve to blow, filling the room with steam, you have to override the automatic settings of either or both of the thermostats of zones 2 and 3 to get rid of some of the excess heat. It may also be necessary to manually turn on the heat-exchanger blowers for zones 1 and 2 for the reasons I previously outlined.

This occurrence is rare, and I generally have about 10 minutes to react to the situation and throw all the manual switches required. After using the system and determining that this is a potential problem, I installed a digital temperature indicator that

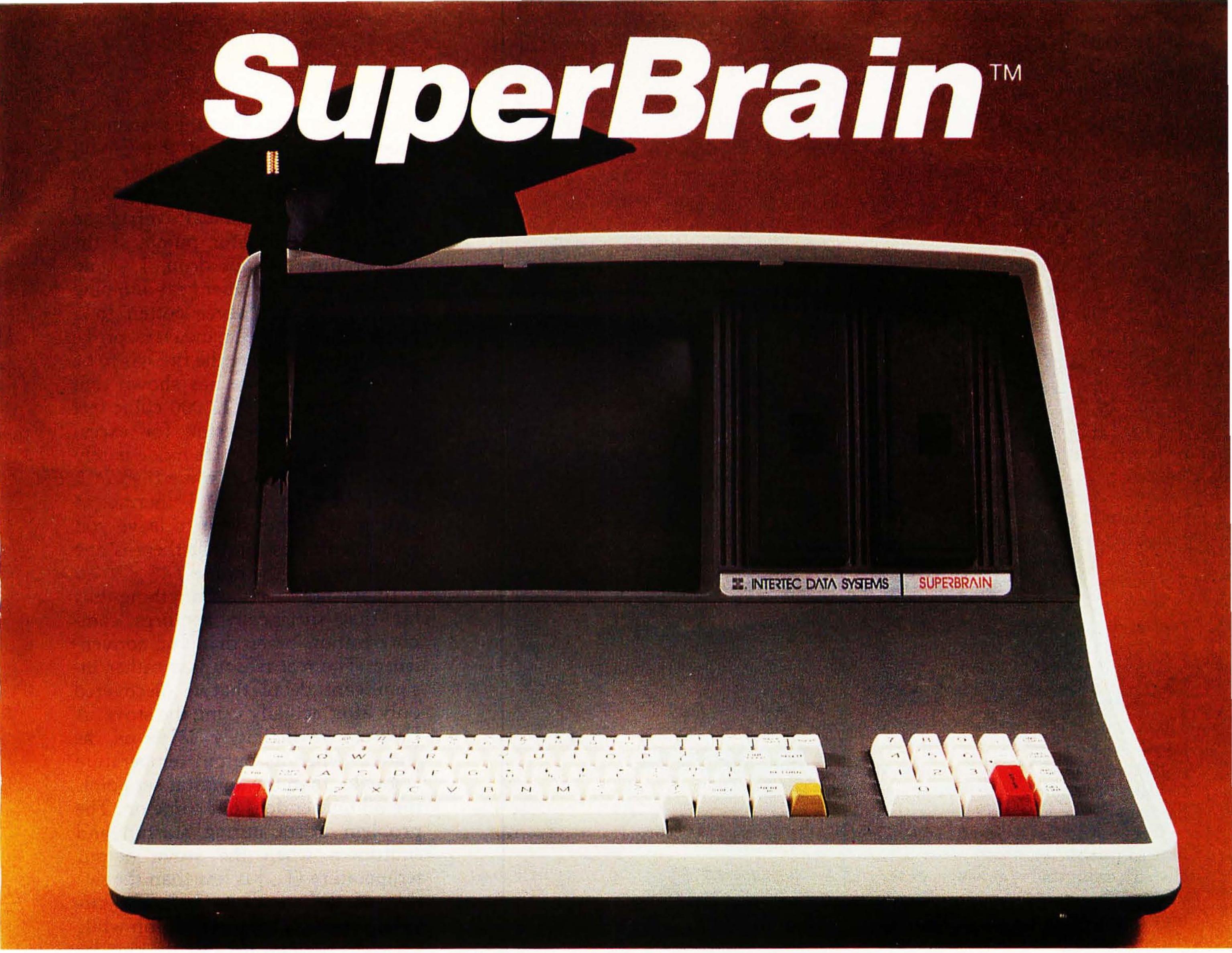
Control Outputs

Signal	Type	Function
TC_1	Contact closure 200 mA	Circulator pump - zone 1
TC_2	Contact closure 200mA	Circulator pump - zone 2
TC_3	Contact closure 200 mA	Circulator pump - zone 3
F_1	Solid state relay 5 A 220 VAC	Heat exchanger blower zone 1
F_2	Solid state relay 5 A 220 VAC	Heat exchanger blower zone 2
XFER	Contact closure 5 A 115 VAC	Oil burner power

Inputs

Status	Level	Function
TC_1	TTL	
TC_2	TTL	0 pump off
TC_3	TTL	1 pump on
F_1	TTL	0 blower off
F_2	TTL	1 blower on
T_{in}	Analog	range 40° to 240° F
T_{out}	Analog	4° to 115° C

Table 1: *Computer I/O lines used with the heating control system.*



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allowed me to monitor the system as I worked at my desk in the Circuit Cellar. When I saw that the temperature was going above 88° C, I would throw the manual override on the zone 2 circulator pump. If the temperature did not drop, I would continue with the other heat dumping methods. It has never gotten to a point where these maneuvers prove insufficient or where the fire has to be put out. Experience has shown that zone 2's volume of 15,000 cubic feet provides a terrific sink for excess heat. Normal use in this mode barely raises its temperature more than 2° F above its nominal 66° F thermostat setting. (I do not want to leave you with the impression that there is one 90° F room in the house.)

I have not described anything thus far that specifically requires computerization other than for convenience. The real reason is a rather insignificant detail that is discovered only after actually using the stove. A Hydrostove definitely saves oil, as stated. When its output temperature is greater than the aquastat set point, the oil burner does not come on. The problem arises during startup and shutdown when the stove output temperature (T_{out}) is less than the setting of the aquastat (T_A). The circulator pump has to remain on while there is a fire but, because the circulation loop is running and returning at less than T_A, the oil burner keeps coming on. *Catch 22!!*

If this were a matter of 10 minutes or so, it would not be so bad; but shutdown to the point where the circulator pump can be turned off can take several hours. The alternative is to cut the power to the oil burner when the wood stove is on and restore it when the fire is out. This is what I initially did, until I was staying up all night to shut the stove off. The alternative was to wake up to a very cold house, turn the oil burner on, and have to wait a half-hour to take a hot shower.

Aside from taking in a tenant who would watch the Hydrostove temperature in exchange for room and board, the only reasonable alternative was a more intelligent control system. With the proper sensors, a device could monitor the heat output of the stove ($T_{out} - T_{in}$), and when it dropped to a predetermined safe point, automatically restore power to

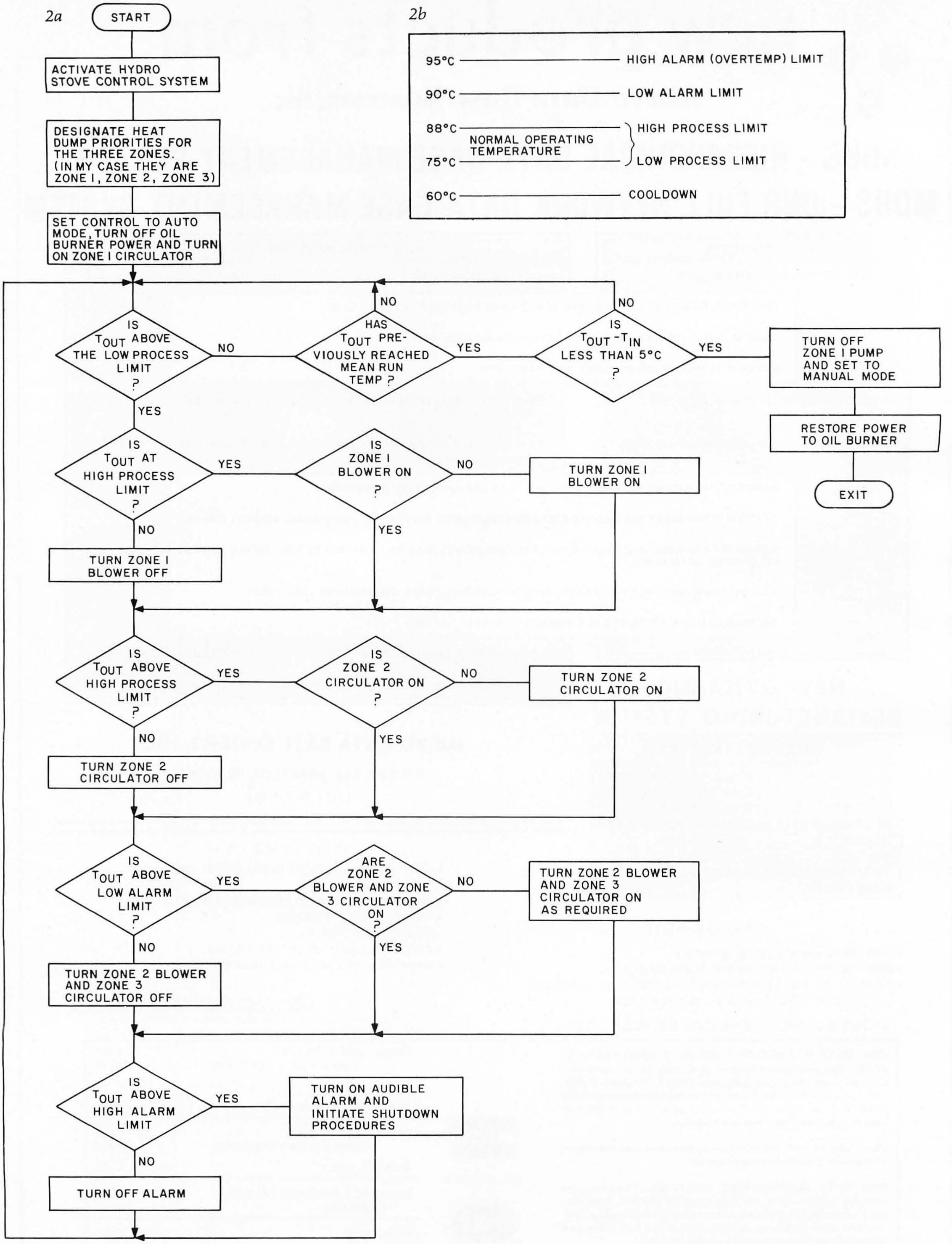


Figure 2: *(a) Logic flow for the automatic distribution of Hydrostove heat when output in a three-zone combination hydro and air heating system. (b) Points of importance in the operating temperature range of the system. The actual set points for process and alarm limits depend upon placement of temperature sensors and may vary a few degrees.*

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Type of wood Hardwoods	Pounds per cubic foot	BTU per cord	Equivalent gallons (gallons per cord) fuel oil
1. White Ash	37.5	23,037,000	165
2. Cherry	31.0	19,043,920	136
3. Hickory	45.0	27,644,400	198
4. Maple (red)	33.5	20,579,720	147
5. Oak (chestnut)	41.0	25,187,120	180
6. Walnut	34.5	21,194,040	151
7. Willow	24.0	14,743,680	105
Softwoods			
8. Douglas Fir	30.0	18,429,600	132
9. Ponderosa Pine	25.0	15,358,000	110
10. White Spruce	25.0	15,358,000	110

Table 2: *Comparison of wood heat values for various species of wood available in North America and their equivalent in gallons of fuel oil per cord of wood. (These estimates are generally accepted by industry.)*

the burner and shut off the circulator-pump override.

Computer-Controlled Heating System

My heating system is not technically a computer-controlled wood stove. It is rather a system designed specifically to efficiently distribute the heat from a wood stove, to safely dump excess heat in an effective manner, and most importantly, to restore the entire system to its standard configuration when the fire is out. I am merely outlining one application of the many that are conceivable when the heating system has been connected to a computer. Complete energy management is a possibility; or, at the very least, total energy output can be closely monitored and recorded. I am working on these areas, but for now, the topic is control.

Virtually any personal computer can suffice as the controller. The logic is straightforward and relatively uncomplicated. It is outlined in the flowchart shown in figure 2. Proper control of the three zones and the Hydrostove requires a special interface to connect the computer to the various blowers and pumps. Table 1 is a list of the signals in question.

The control outputs from the computer are, in essence, all contact closures, whether it be through mechanical or solid-state relays. The use of relays provides electrical isolation between the computer and the heating system. It further prevents potentially dangerous loops between 115- and 220-VAC powered components.

The three zone thermostats are low-voltage AC circuits that can be directly controlled through a reed relay, as shown in figure 3. The relay contacts are connected in parallel with the thermostat. With the thermostat contacts open, a logic 1 control signal closes the relay and provides an alternate current path to pull in the pump-start relay. By monitoring the voltage across the relay contacts, it is possible to directly monitor the activity of the circulator pump and determine its operational status at any time. If the contacts are open, current flows through the optoisolator *light-emitting diode* (LED), producing a logic 0 status at the output. When closed, no current flows and the logic value is 1. My application required only the ability to turn on a pump which may not already be running. However, to accommodate complete functional control of the pumps, the thermostat can be disconnected as shown.

The interface to the heat exchanger blowers, shown in figure 4, is similar. This time however a solid-state 7 A 220 VAC relay is used. The power to the blower is 5 A 220 V rather than low voltage AC as before. A 7 A solid-state relay was chosen because of its size and low cost.

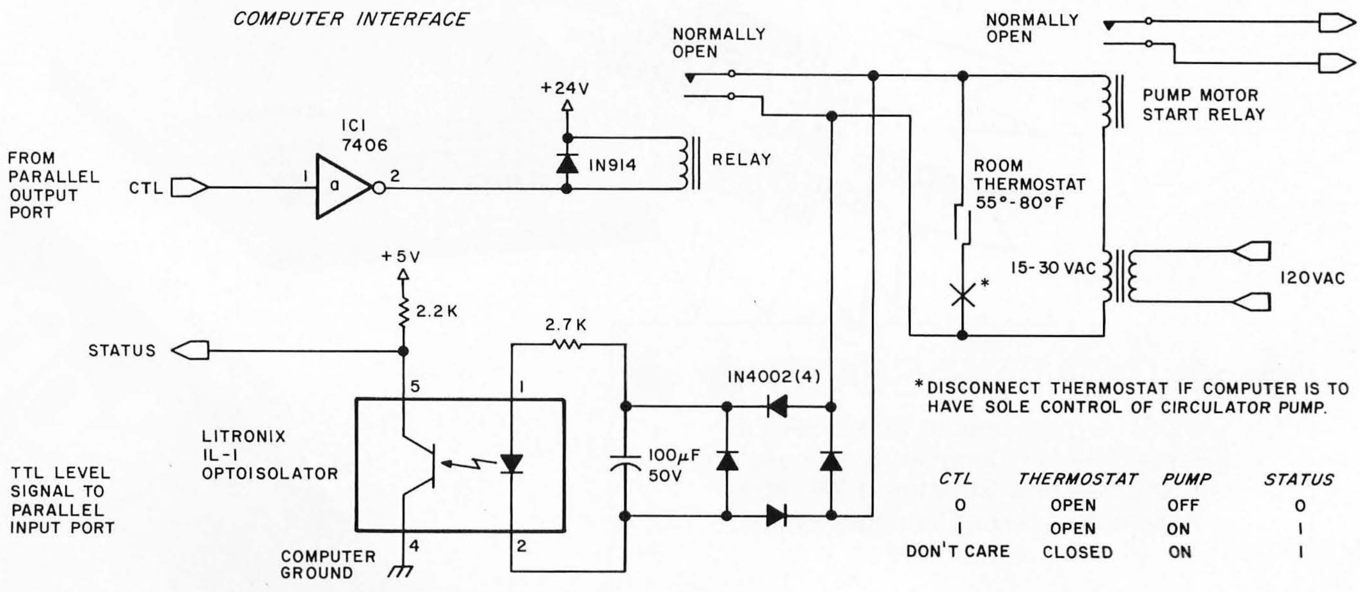


Figure 3: *Isolated interface for computer control of a typical oil-fired, hot-water, 1/4-horsepower circulator pump. The 7406 open-collector inverter (IC1) requries a 5 V supply to pin 14 and a ground connection to pin 7.*

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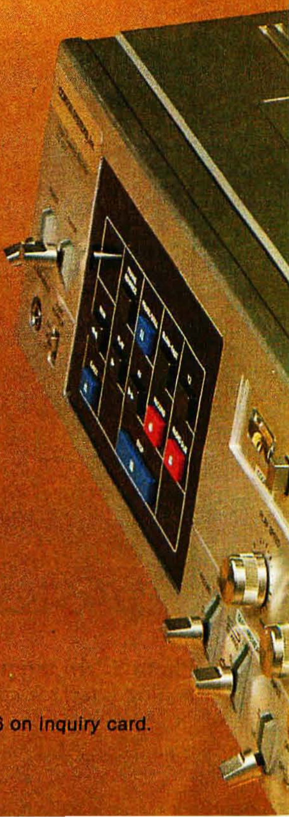
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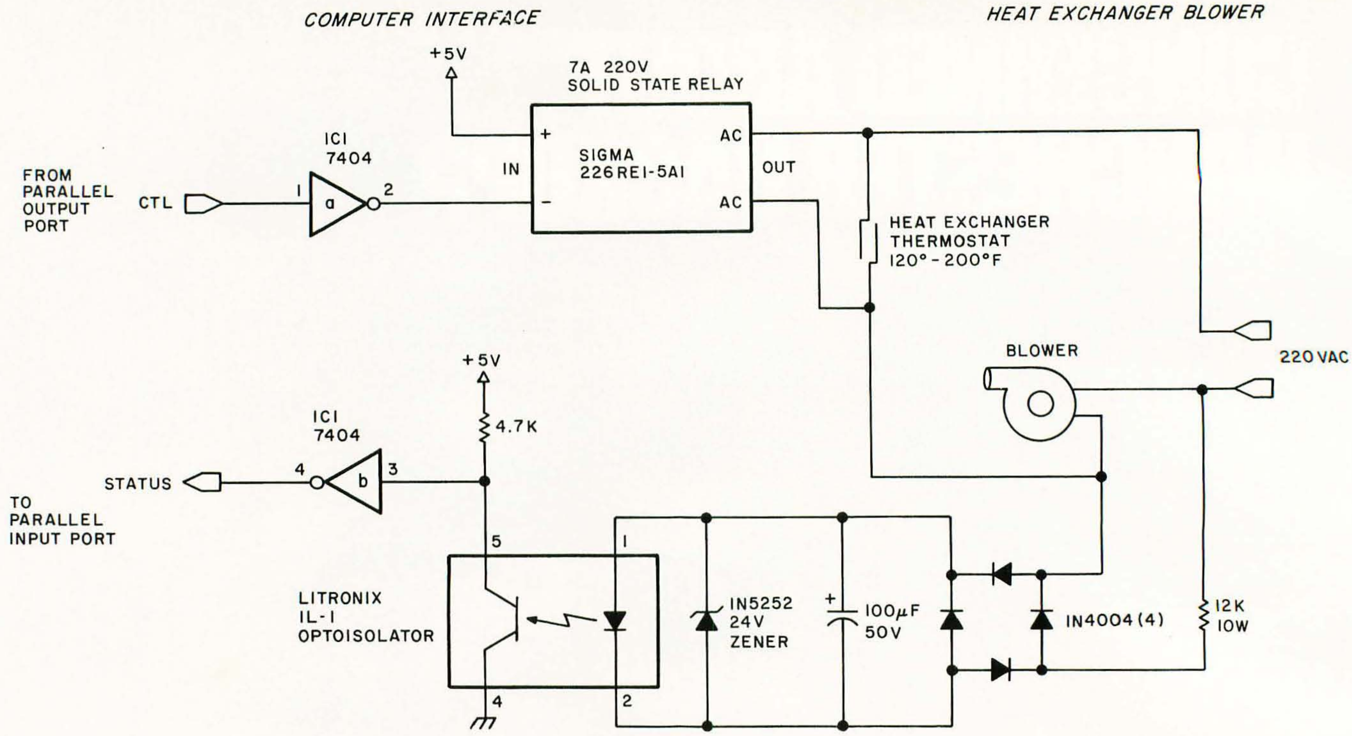
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CTL	THERMOSTAT	BLOWER	STATUS
0	OPEN	OFF	0
1	OPEN	ON	1
DON'T CARE	CLOSED	ON	1

Figure 4: *Isolated interface for computer control of a heat-exchanger blower fan. The 7404 hex inverter requires a 5 V power supply to pin 14 and a ground connection to pin 7.*

Monitoring the activity of the blowers is accomplished simply by checking the voltage across the motor. The 220 V present when the motor is on is reduced and rectified to run an optoisolator as before. With voltage present, the status output is high (logic 1).

Finally, the computer must be able to monitor the output temperature of the Hydrostove. This signal is an analog voltage that is proportional to temperature. Various sensors such as thermistors or thermocouples could be used, but a more practical device is a temperature sensor device such as the LM334 from National Semiconductor. When configured as in figure 5, the output of IC1 (monitored at V_{in}) is 10 mV per degree Celsius. It may have a nominal offset of something like 2.5 V, but if the temperature rises 10° C the output will go up 100 mV. ICs 2 and 3 provide gain and offset adjustment and are configured to prohibit accidental negative excursion of the output if the temperature sensor goes open circuit. The result is a circuit that converts a change in temperature to a change in voltage. By adjusting the gain and offset, 0° C can be an output of 0 V and 100° C can be 1 or 10 V. A Fahrenheit scale can be just as easily calibrated by setting a different gain and offset.

To read this signal, the computer must have an analog-to-digital converter interface. This can be either a true successive-approximation analog-to-digital converter as in figure 6, or the discrete set-point level detector of figure 7. The choice

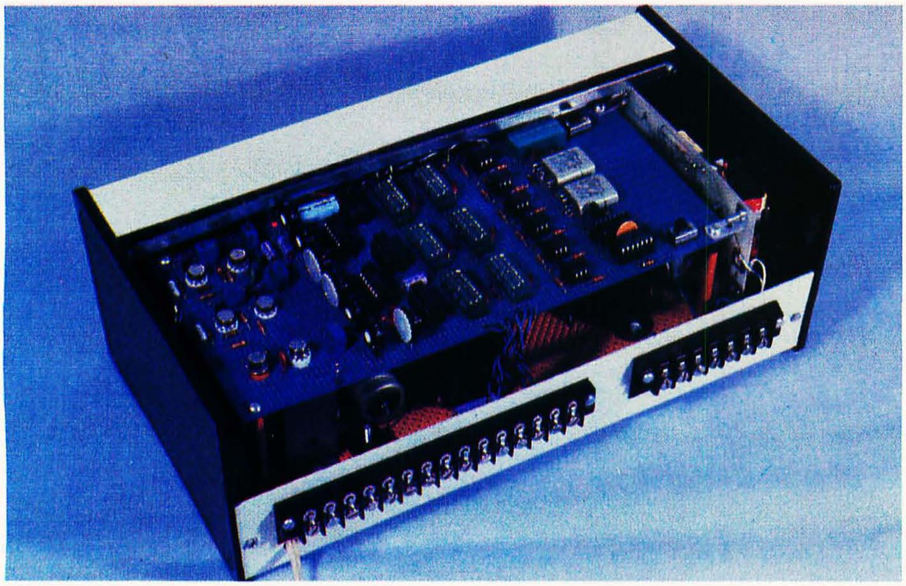


Photo 5: *An internal view of the I/O controller containing relays, optoisolators, and analog interface components.*

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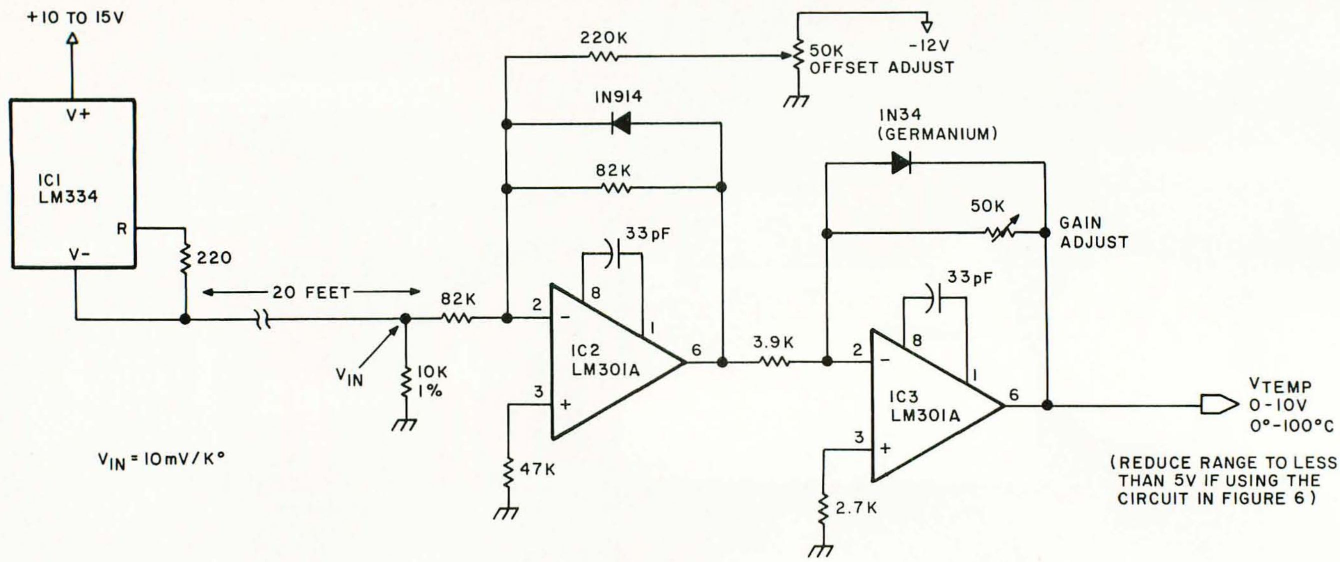


Figure 5: *Solid-state temperature sensor. The range of the output voltage (V_{TEMP}) is reduced to less than 5 V if the circuit in figure 6 is used.*

depends upon whether you need to know the exact temperature or just significant set points.

If data acquisition is the dominant consideration, then consider the circuit of figure 6. IC8 is an 8-channel, 8-bit analog-to-digital converter that is bus-compatible with most microprocessors. Figure 8 outlines its internal structure. As configured, it is attached to function as ports F8 through FF, with port F8 corresponding to input channel 0, and port FF corresponding to channel 7. The voltage on channel 0 is read by initiating an output to port F8. This causes the address of 000 to be stored and the conversion process started. After about 100 microseconds, the time necessary for conversion, the channel analog value can be obtained by reading an input from port F8. A similar procedure is used to set and read the other channels.

If you are interested strictly in control, then the circuit of figure 7 is much simpler to use. If a 0 to 10 V input represents a range of 0 to 100° C and there are eight comparators, each could be set to trigger 12.5° C higher than the preceding one. A better approach is to arrange the majority of set points to cover the control and alarm range rather than to cover insignificant temperature ranges. For example, bit b_0 could be set to trigger at 60° C. It is not necessary to care much about temperatures below that point. The range of prime interest is from about 75° C to 95° C. Dedicating 5 set points within this range, another perhaps between 60° C and 75° C and a final overtemp indicator at 98° C should prove more than adequate.

My system uses a combination of both interfaces, using set points for control inputs and a true analog-to-digital converter to determine actual heat output from the stove.

A further enhancement is a visual display indicating the real-time status of the system components and a readout of the actual temperature. The prototype controller is shown in photos 4 and 5. It serves as the interface between the heating system and the computer, and contains most of the electronics described in this article as well as other enhancements not discussed at this time. While all the control decisions are actually made by the computer, the display gives me

Text continued on page 56

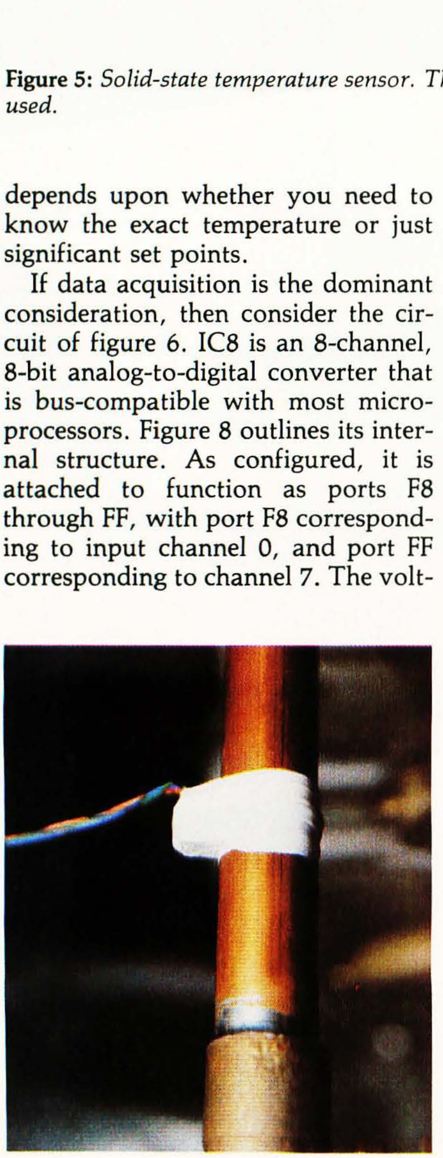


Photo 6: *To effectively use this control device, it is important to have accurate temperature measurements. The LM334 temperature sensor is easily attached to the Hydrostove return pipe by wrapping Teflon plumbing tape around it.*

Number	Type	+5 V	GND	−12 V	+15 V
IC1	LM334	see figure 5			
IC2	LM301A			4	7
IC3	LM301A			4	7
IC4	LM339		12		3
IC5	LM339		12		3
IC6	REF-01	see figure 7			
IC7	LM301		4		7
IC8	ADC0808	see figure 6			
IC9	74LS30	14	7		
IC10	74LS02	14	7		
IC11	7400	14	7		

Table 3: *Power and ground connections for the integrated circuits that are used in the circuits of figures 5, 6, and 7.*



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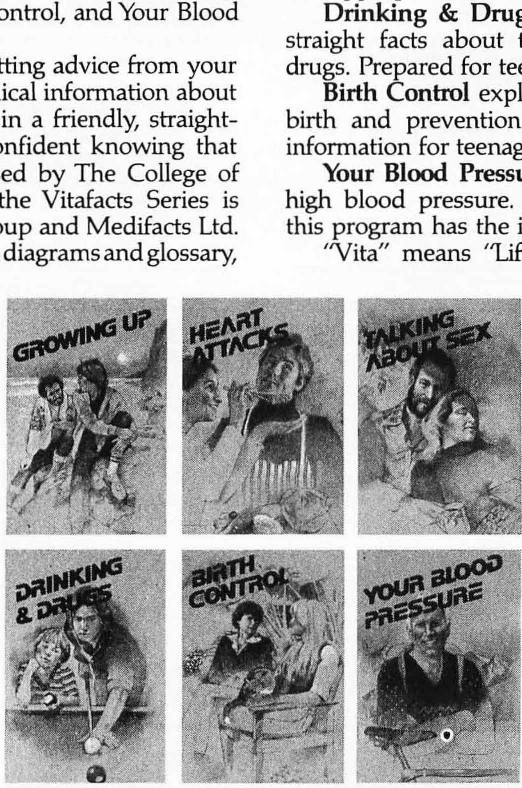
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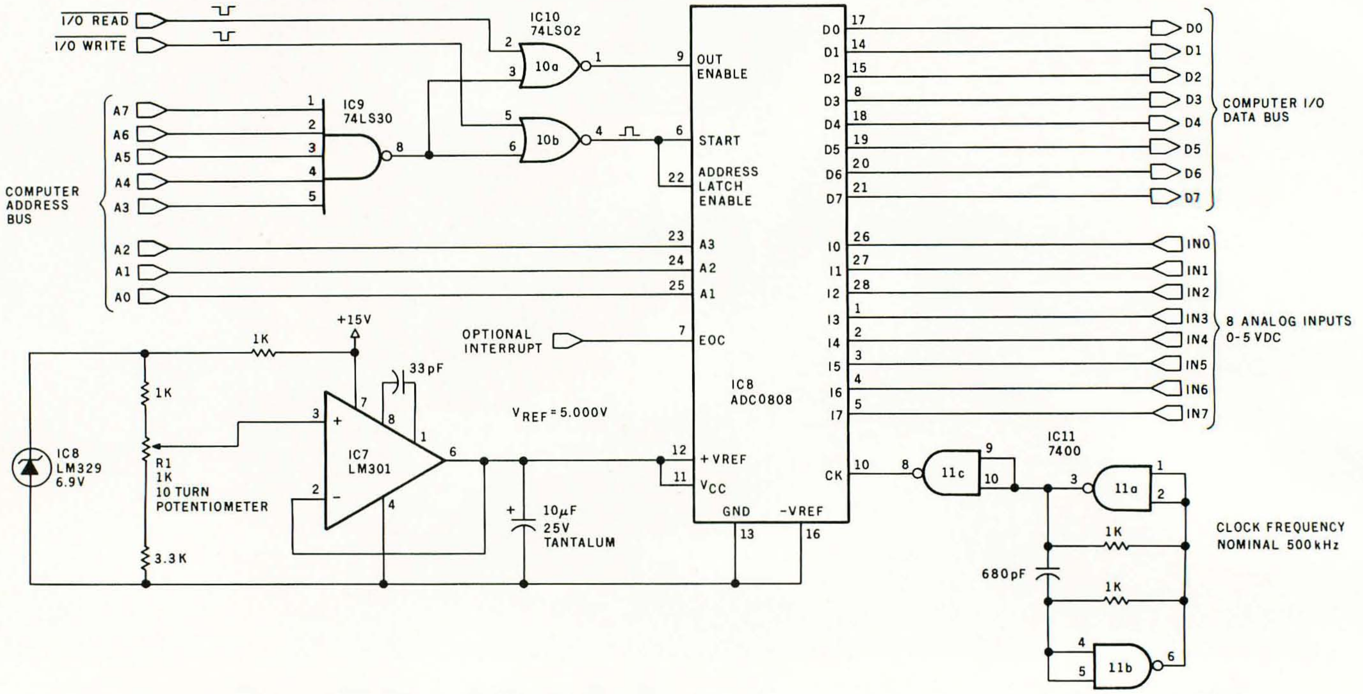


Figure 6: *An 8-channel, 8-bit analog-to-digital (A/D) converter using a National Semiconductor ADC0808 data acquisition device.*

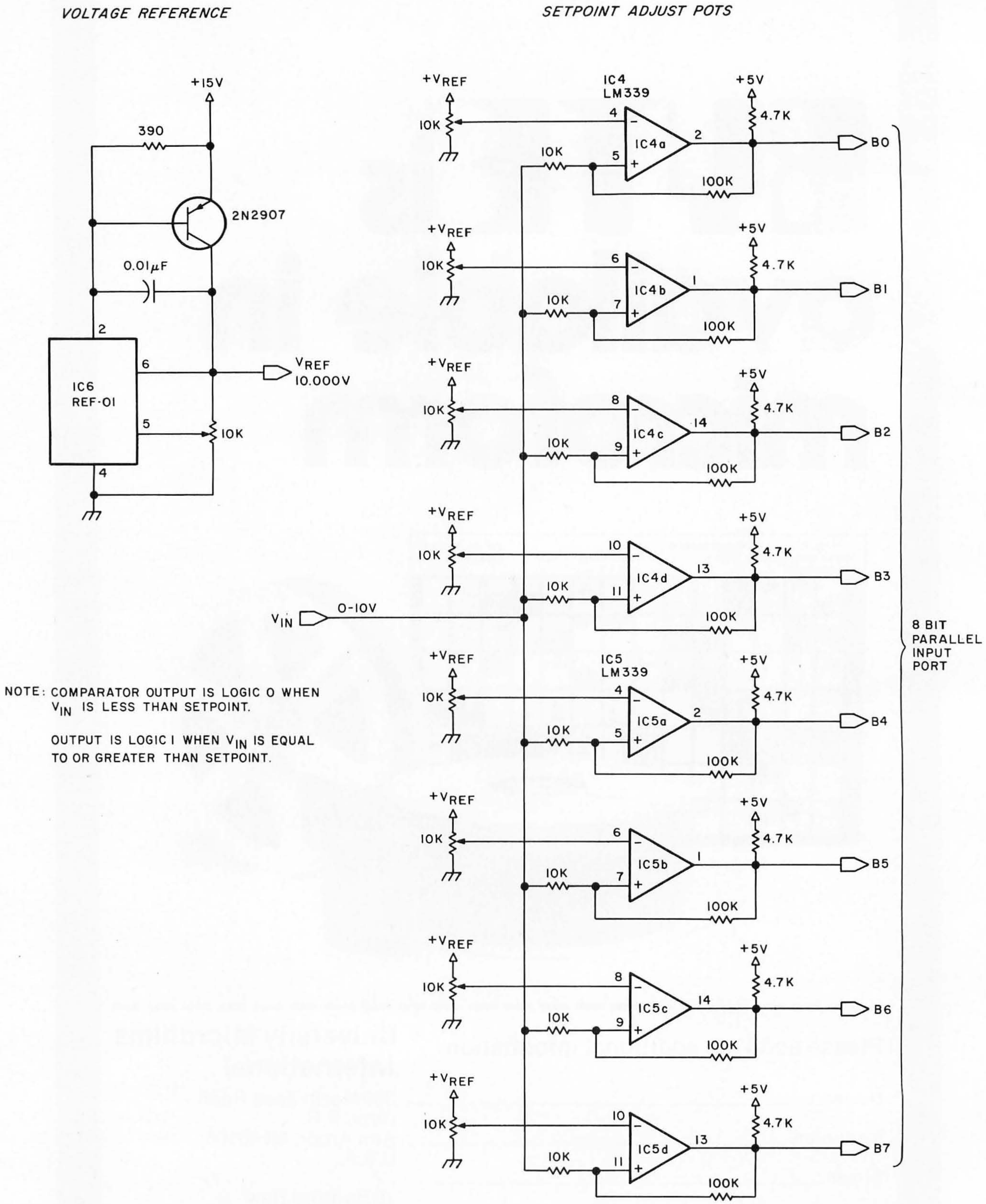


Figure 7: *A discrete set-point-level detector. This method is cheaper than the method shown in figure 6 and can be used only when it is necessary to detect a small number of temperature ranges. The eight comparators on the right-hand side of the figure are wired to have their outputs go from logical 0 to logical 1 when a certain temperature (determined by the position of the 10 K potentiometer) is exceeded. The status of the eight bits can be used to determine what range of temperature the interface is currently in. The voltage reference integrated circuit REF-01 (IC1) may be obtained from Precision Monolithics, 1500 Space Park Dr, Santa Clara CA 95050.*

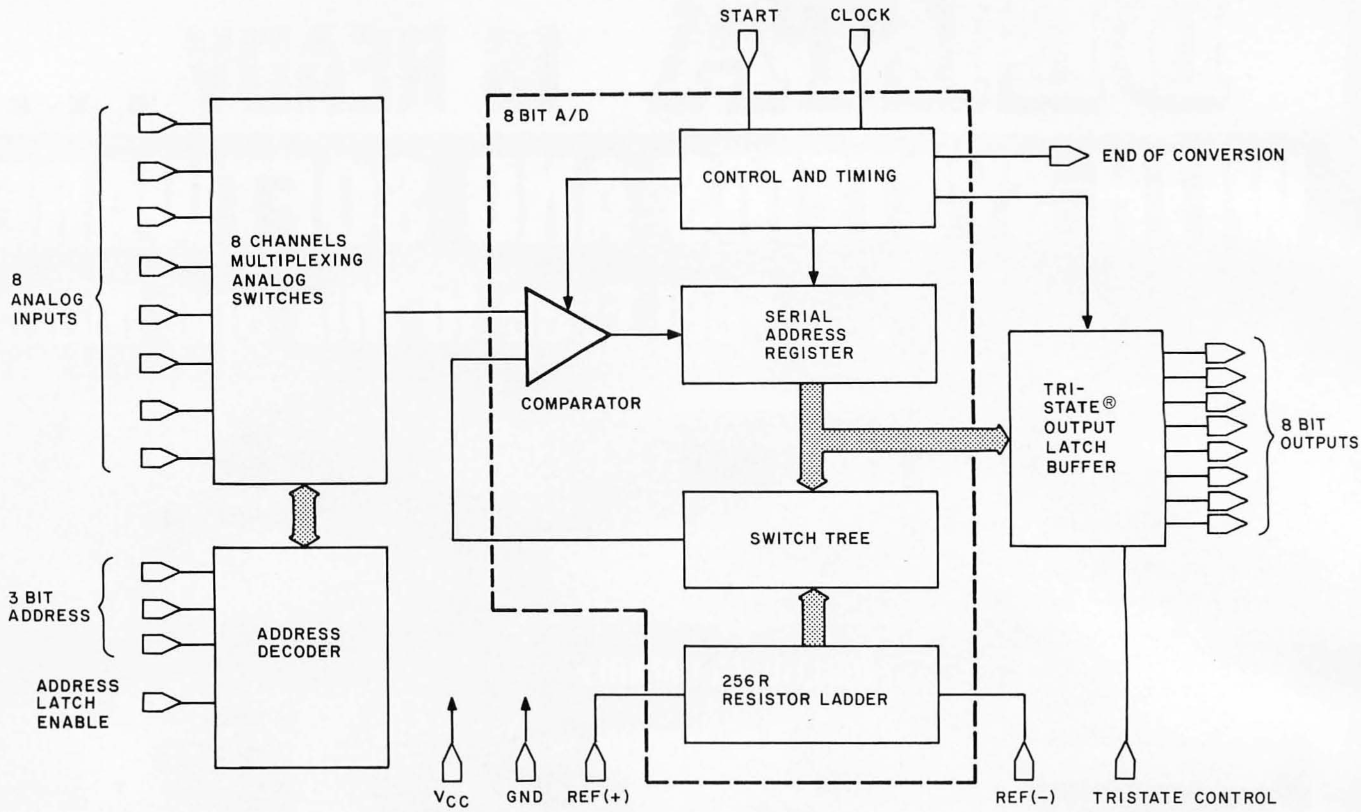


Figure 8: *National Semiconductor's ADC0808/0809 CMOS data acquisition system. The 8-bit converter uses successive approximations. The device interface is to most 8-bit microprocessors.*

Text continued from page 50:
the added satisfaction that everything is working correctly.

Back to Roger's Visit

Roger studied the stove very carefully. He was surprised at the simplicity of the idea of supplemental wood heat, but somewhat aghast at the overall complexity of the entire system. The concept of computer control did not concern him in the least but I sensed that my apparent independence from OPEC fostered a little competitive jealousy.

"What about wood? You still will have to get wood for the stove," Roger commented, pointing out a possible serious limitation.

"I'm surprised you didn't notice when you drove in. There are eight cords of wood piled outside. I don't expect to use them all this winter. Wood, unlike oil, is one of those things you can easily stockpile if you have enough storage space."

"Oh yeah, I did notice a few piles beside the driveway."

Roger was perplexed. He had obviously begun to believe the petroleum company propaganda. The thought of missing an oil delivery meant total destruction of civilization as far as he was concerned. But he just could not believe that the addition of a wood stove meant independence. Suddenly he smiled as he thought of a sobering reality that I might have overlooked.

"You have to keep the circulator pumps running when the stove is going, right? And if the fire is real hot you may in fact need the blowers on as well?"

"Sure, why?"

Roger had found the Achilles' heel of my heating system. The Hydrostove as I had it configured needed power to run all the pumps and blowers. The actual heat might come from a wood fire, but distribution of the heat throughout the house depended upon the local electric utility. Roger quickly commented, "What happens if the power goes out?"

"Well, I suppose I should be concerned, but I'll have four or five minutes to react."

Roger laughed. "React to what? Living in a steam bath?"

"Perhaps I should show you. Follow me." I led Roger out of the cellar into the garage. In one corner was a large mechanical contraption, part of which was a two-cylinder engine. Pipes and wires came to it from different directions, all converging at a central control box adjacent to the motor. Without explaining the intricate details involved with this permanent installation (the heating system was enough for Roger this time) I said, "If the utility power goes out, I throw the emergency transfer switch and start my 5-kilowatt generator. It's large enough to run the whole house and then some."

Hesitating, then striking out with one last effort, "You still need gasoline and that doesn't look like a very big tank."

"Sorry Roger, I thought of that too. This particular unit runs on both gasoline and propane. There's a 100-gallon propane tank outside the garage just for the generator"

"I give up!"

It is just as well that he did. Eventually he would notice the trench going across the driveway from the house to the new garage. When he is installing the wiring for it I hope he doesn't ask why I am running insulated copper pipes underground across to the garage.

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Solving Problems Involving Variable Terrain

Part 1: A General Algorithm

Scott T Jones
271 NW 38th St
Boca Raton FL 33431

A General Definition of Terrain Problems

In business, in industry, and especially in conflict simulation, problems are often confronted that involve terrain, the surface of the planet Earth. These problems can usually be expressed in terms of movement on a map. This article defines terrain as any feature on the map that affects movement. The term *movement cost* will be defined as the quantitative effect of the terrain on movement.

An example of a hiker traveling cross-country from one town to another town will be used. The hiker may travel one mile across level ground in 15 minutes, while requiring 30 minutes to travel one mile when the ground is sloping gradually upward. It can be said that the *movement cost* for the terrain called level ground is one, while the movement cost of the terrain called upward-sloping ground is two. Here the movement cost is in terms of time.

For another example, consider a construction company building a road. The cost to build one mile of roadway over solid ground might be $100,000, while the cost to build one mile of road over marshy ground might be $500,000. Thus, you can say that the movement cost is one for solid terrain and five for marshy terrain. In this case, the movement cost is expressed in terms of money.

In both examples, there is an existing problem of moving from one point to another across a terrain map while incurring the minimum movement cost. Now examine another variation of this problem.

Consider a cable television company that is investigating the extension of underground coaxial cables out to a new area. It is known that these new cables will provide a fixed return on investment due to the increased number of customers. Therefore, only a fixed amount of money can be spent to place these cables. Using a map of the terrain and the known costs of placement over the various types of terrain to be encountered, the company can decide whether the extension is feasible.

The purpose of this article is to describe a general solution to these and other related problems.

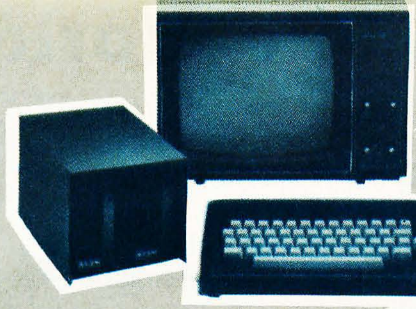
Representing Generalized Terrain Problems

The first step in solving a terrain problem is to superimpose a grid on the map that is to be used. This will allow you to refer to each location on the map via its coordinates and identify a particular type of terrain with each location.

For simplicity, a standard rectangular grid and coordinate system will be utilized. The map is now a matrix of squares that can be referred to by their row and column in the matrix. The size of the squares should be chosen so that each square effectively has only one type of terrain in it.

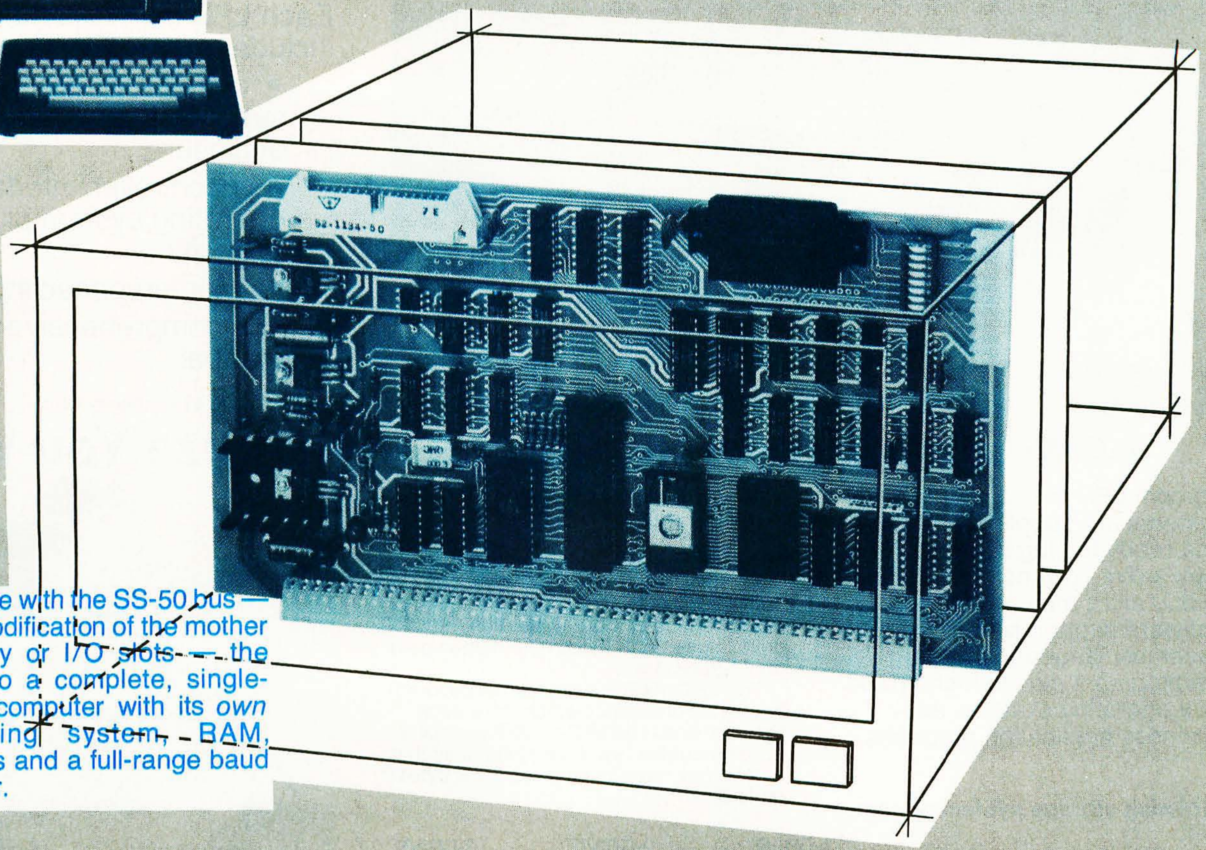
The second step is to determine the movement cost for each type of terrain. This requires that a study be made to determine the type of cost involved in the problem. This cost must then be scaled so the movement-cost figure for

Text continued on page 62



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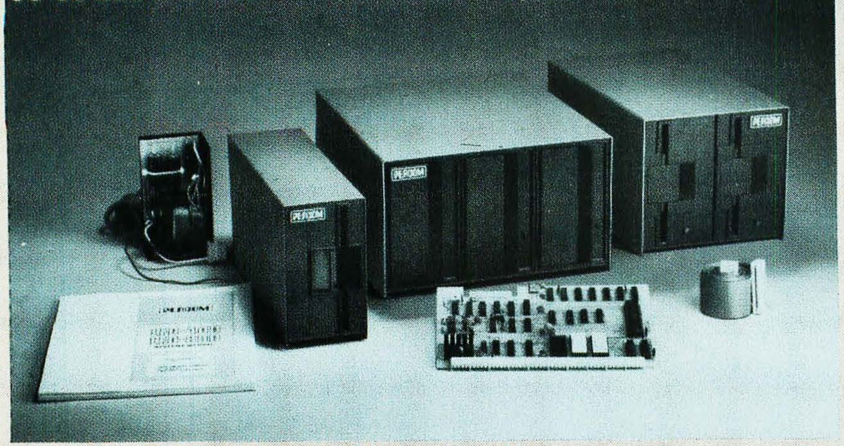
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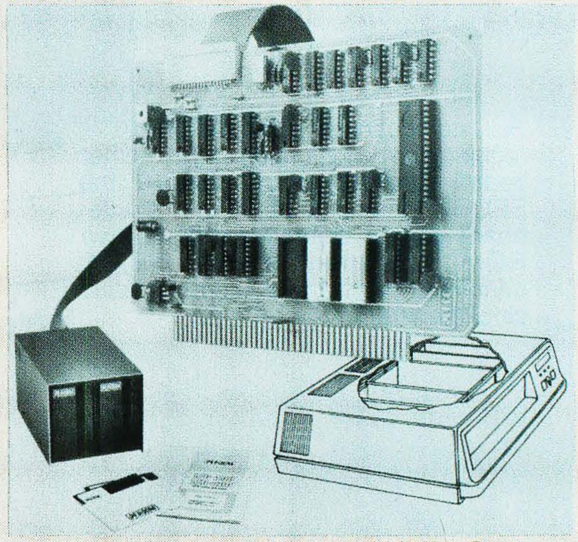
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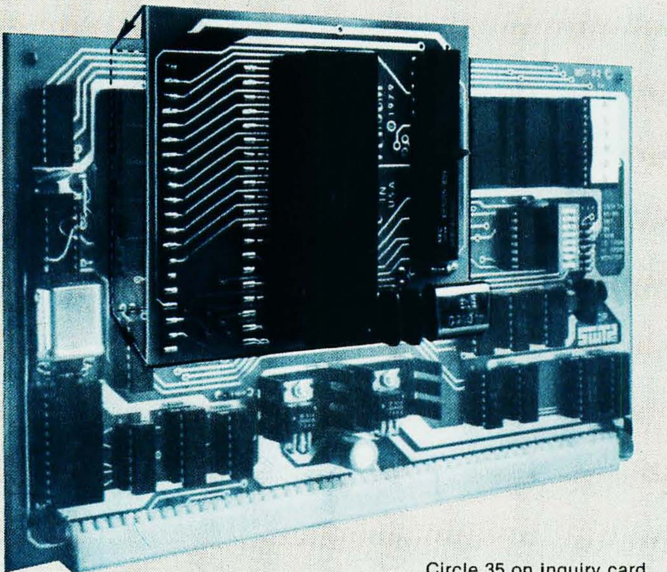
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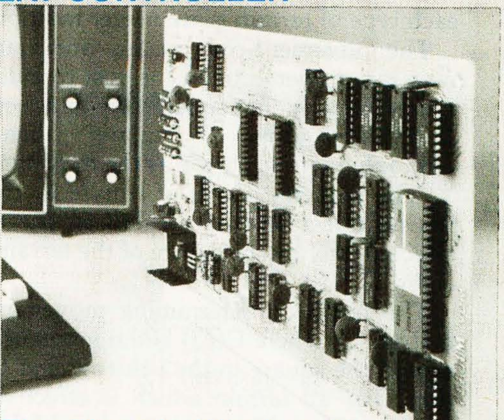
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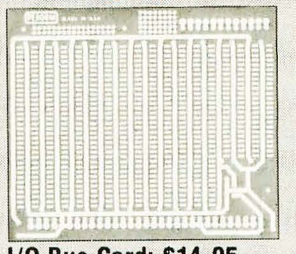
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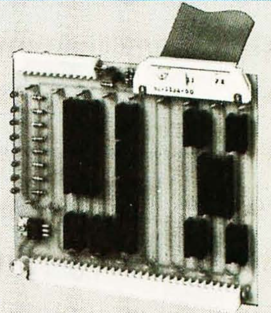
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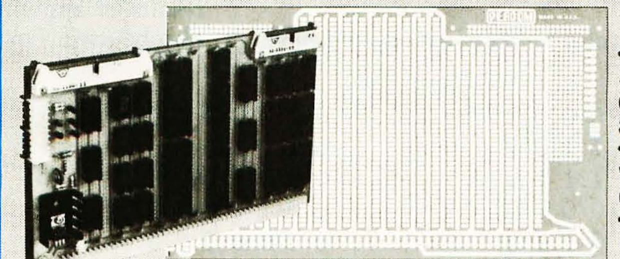
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Text continued from page 58:
each type of terrain is an integer multiple of the cost unit.

The movement cost for any one square on the terrain map is considered to be the cost to *enter* the terrain area represented by that square. If you are currently in square X, and wish to move to square Y, then consider the cost of moving *into* square Y as the movement cost for square Y. The movement cost of square X, the current square, has no effect on the calculation; the movement cost is affected only by the nature of the terrain you are about to enter.

The result of determining movement costs is a cost matrix, C, where $C(I,J)$ is the movement cost of the terrain in the square in the I-th row and J-th column of the map. For all terrain which is effectively impossible to enter, or for which entrance is prohibited, $C(I,J) = 0$ is assigned.

The third step is to generate *terrain masks*. First determine *max*, which is the maximum value found among all the movement costs in C. Then for all values k such that $1 \le k \le C_{max}$ you define the terrain mask Tk where $Tk(I,J)$ is 1 if $C(I,J)=k$, and $Tk(I,J)=0$ otherwise.

Now you should define a *scatter function* for the problem. The function will produce scatter mappings for use with the terrain masks generated above. The input to this function is a boolean array of starting positions (1, if yes; 0, if no). The output is another boolean array of ending positions of moves of distance one from the starting positions. Since distance is a factor, you must define a *metric*, or distance function, for this problem.

W	W	W	W	W	W	W	W		blank	=	Clear
W	W	R	R			W	W				
W		R	R				W		R	=	Rough
W		R	J	J	J		W				
W		J	J	J			W		J	=	Jungle
W		J				W	W				
W				W	W	W	W		W	=	Water
W	W	W	W	W	W	W	W				

Figure 1: *Map of a small island with clear, rough, and jungle terrain. The map is represented on a rectangular grid.*

0	0	0	0	0	0	0	0	
0	0	2	2	1	1	0	0	
0	1	2	2	1	1	1	0	C
0	1	2	3	3	3	1	0	
0	1	3	3	3	1	1	0	
0	1	3	1	1	1	0	0	
0	1	1	1	0	0	0	0	
0	0	0	0	0	0	0	0	

Figure 2: *A movement cost matrix for the island map of figure 1.*

Example of the Procedure

In figure 1, there is a map of a small island with terrain of three types: clear, rough, and jungle. The map has been placed on an 8 by 8 rectangular grid, and each grid square is clearly identified as being a single type of terrain.

Let us return to our hiker traveling cross-country on foot. Suppose that he requires 10 minutes to travel through one square of clear terrain, 20 minutes for rough terrain, and 30 minutes for jungle terrain. The terrain type "water" is effectively impassable in this problem. Thus, the movement cost is in terms of 10-minute periods of time, and you can construct the cost matrix C as shown in figure 2. Since 3 is the maximum movement cost value found in C, you will have three terrain masks: T1, T2, T3 as shown in figure 3.

Using a rectangular grid, there is a choice between two obvious distance functions with strictly integer values. The first distance function is the "city" metric, which defines the distance between points (a,b) and (c,d) as $|a-c| + |b-d|$ where $|x|$ is the absolute value of x. This function derives its name from the fact that in the rectangular system of streets found in a city, no movement is allowed diagonally through blocks. All distances are in terms of the net distance north or south added to the net distance east or west.

The second distance function is the "square" metric, which defines the distance between points (a,b) and (c,d) as the maximum of $|a-c|$ and $|b-d|$. Its name is derived from the fact that the shape of the area containing all squares that are N or less units distant is a square, for any integer N.

Scatter Functions

Now it is necessary to define scatter functions CSC and SSC for the "city" and "square" distance functions, respectively. Let A be a matrix the same as C; that is, an 8 by 8 matrix. Let $A(I,J)=0$ for all I and J, except for the one location on the map that is to be used as the starting position. $A(I,J)$ will be 1 for the starting location. Matrix A is the input to the scatter function. B will be designated as the output matrix. The notation X(A) to represent the results of applying the function X to the matrix A will also be used. For the city distance function, the function

T1

0	0	0	0	0	0	0	0
0	0	0	0	1	1	0	0
0	1	0	0	1	1	1	0
0	1	0	0	0	0	1	0
0	1	0	0	0	1	1	0
0	1	0	1	1	1	0	0
0	1	1	1	0	0	0	0
0	0	0	0	0	0	0	0

T2

0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0
0	0	1	1	0	0	0	0
0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

T3

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	1	1	1	0	0
0	0	1	1	1	0	0	0
0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Figure 3: *The three terrain masks that will be superimposed on the movement cost matrix of figure 2.*

a. A	b. CSC(A)	c.CSC(CSC(A))	d. SSC(A)	e.SSC(SSC(A))
0 0 0 0 0	0 0 0 0 0	0 0 1 0 0	0 0 0 0 0	1 1 1 1 1
0 0 0 0 0	0 0 1 0 0	0 1 1 1 0	0 1 1 1 0	1 1 1 1 1
0 0 1 0 0	0 1 1 1 0	1 1 1 1 1	0 1 1 1 0	1 1 1 1 1
0 0 0 0 0	0 0 1 0 0	0 1 1 1 0	0 1 1 1 0	1 1 1 1 1
0 0 0 0 0	0 0 0 0 0	0 0 1 0 0	0 0 0 0 0	1 1 1 1 1

Figure 4: *Figure 4a is an example of a starting matrix, A. Figure 4b represents the matrix after the CSC (city) scatter function has been applied. The CSC function is then applied a second time to obtain the matrix in figure 4c. Figures 4d and 4e represent the results obtained after applying the SSC (square) scatter function to the matrix in figure 4a once and twice.*

CSC will assign to each element of B the value:

$$B(I,J) = CSC(A(I,J)) = A(I,J) \text{ OR } A(I,J+1) \text{ OR } A(I,J-1) \text{ OR } A(I+1,J) \text{ OR } A(I-1,J)$$

where OR represents the logical OR operation. For the square distance function, the function SSC will assign to each element of B the value:

$$B(I,J) = SSC(A(I,J)) = A(I,J) \text{ OR } A(I,J+1) \text{ OR } A(I,J-1) \text{ OR } A(I+1,J) \text{ OR } A(I-1,J) \text{ OR } A(I+1,J+1) \text{ OR } A(I+1,J-1) \text{ OR } A(I-1,J+1) \text{ OR } A(I-1,J-1)$$

In both cases, all matrix elements $A(I,J)$ that lie outside the matrix A are to be considered zero, such as A(0,0).

Figure 4a gives an example of a 5 by 5 starting matrix, A. Figure 4b represents the result of applying the CSC function to that matrix. In figure 4c, the result of applying CSC to the matrix in figure 4b can be seen. Figures 4d and 4e represent the matrices obtained after one and two applications of SSC to the matrix in figure 4a.

Solving General Terrain Problems

You now have everything needed to solve terrain problems: a map with a grid and coordinate system, a movement cost matrix, a set of terrain masks, a matrix of starting positions, and a distance function with associated scatter function.

These solutions will probe all possible paths, incrementing by one unit at a time until your resources are exhausted or your goal is reached. If you reach the goal before you run out of resources, the proposed journey is feasible; if you can reach the goal only after running out of resources, the proposal is not feasible. Furthermore, once a proposed journey is proven to be feasible, you can then retrace the path from the goal back to the starting position to determine an optimal solution to the problem.

Now reconsider the problem of the man walking on the island of figure 1. The city metric and the scatter function CSC will be used. Let the walker's starting point be the square (3,5) on the map in figure 1; that is the clear terrain in the third row and the fifth column. During the first 10 minutes the hiker will expend one unit of cost and can, therefore, move one square north to (2,5) or one square east to (3,6). The hiker cannot move south or west to (4,5) or (3,4) since he has not yet expended enough cost units. Figures 5 and 6a show his starting location matrix and his matrix of possible new locations after 10 minutes, since each of these positions requires only one more unit of movement cost. After another 10 minutes, the hiker can reach the clear terrain squares at (2,6) and (3,7) by moving from the squares reached after first 10 minutes. The hiker could also have reached the rough terrain square (3,4). This would be possible by moving west for 20 minutes from the starting position at square (3,5). All

other moves are impossible due to either a lack of sufficient travel time, in the case of the jungle square (4,5), *or* the presence of impassable terrain, such as the water to the north. Figure 6b shows the possible new locations for the hiker after 20 minutes (two units of movement cost expended).

After 30 minutes, the hiker has finally expended enough units of movement cost to go south from his starting position to the jungle terrain square (4,5). He can now also reach the rough terrain square (2,4) by traveling west for 20 minutes from the clear terrain square (2,5). Figure 6c shows the hiker's possible locations after 30 minutes.

From the above example, it should be clear that movement into terrain with a movement cost of k depends on the position of the object k movement cost units before. Refer to each iteration of the example above as a move. Also, designate the matrix of possible locations after k moves Mk or the k-th scatter mapping.

This relation can be expressed as follows: the new terrain squares of movement cost k that you can reach on move n is represented by the matrix A where $A(I,J)$ is equal to $Tk\ (I,J)$ AND $B(I,J)$ where $B = XSC\ (Mn-k)$. (XSC is the scatter function. AND represents the logical AND operation.) From this you obtain the relation:

$$\begin{aligned} Mn = Mn-1 \text{ OR } & (T1 \text{ AND } XSC\ (Mn-1)) \\ \text{OR } & (T2 \text{ AND } XSC\ (Mn-2)) \\ & \vdots \\ \text{OR } & (Tk \text{ AND } XSC(Mn-k)) \end{aligned}$$

where k is the minimum of C_{max} and n. In both of these relations, function XSC could be replaced by CSC, SSC, or any other scatter function to allow the use of any other metric or even another grid system, such as *the hexagonal* grid. The hexagonal grid will be discussed in part 2 with reference to conflict simulations. Figure 7 shows the scatter mappings M1, M2 and M3 using the square scatter function, SSC. It is left to the reader to verify that this relation holds for both scatter functions.

Using scatter maps, you can prove or disprove the feasibility of these proposals by determining whether this goal is a possible new location in the scatter mappings.

Determining an Optimal Path

Suppose that after n moves, the scatter map Mn finally contains the goal. Therefore, you know that there exists a path from your starting location to the goal which requires a movement cost of n, and you know that no less expensive path exists. To find this path it is necessary to first define the matrices Sk that are the sums of all the

```
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 0        M0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
```

Figure 5: *The starting matrix for the island problem with the traveler standing in the clearing at location 3,5.*

```
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 0     0 0 0 0 1 1 0 0     0 0 0 1 1 1 0 0
0 0 0 0 1 1 0 0     0 0 0 1 1 1 1 0     0 0 0 1 1 1 1 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 1 0 1 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0
     a. M1               b. M2               C. M3
```

Figure 6: *After 10 minutes, the traveler may be in any of three positions (figure 6a). Each of these positions represents a 10 minute or less expenditure of time. After another 10 minutes, the traveler may be in any of the squares indicated by figure 6b. Figure 6c represents squares where the traveler may be after 30 minutes.*

```
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0
0 0 0 0 1 1 0 0     0 0 0 1 1 1 0 0     0 0 0 1 1 1 0 0
0 0 0 0 1 1 0 0     0 0 0 1 1 1 1 0     0 0 0 1 1 1 1 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 1 0     0 0 0 1 1 1 1 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 1 1 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0     0 0 0 0 0 0 0 0
     a. M1               b. M2               C. M3
```

Figure 7: *The first, second, and third scatter-function mappings using the square scatter function (SSC) as defined by equations in text.*

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0	0	0	0	0	0	0	0	0
0	0	0	1	3	2	0	0	
0	0	0	2	4	3	2	0	
0	0	0	0	1	0	1	0	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	

S3

Figure 8: *The third scatter sum using the city scatter function (CSC) for the island example. All moves which are made must conform to the city metric (distance function).*

scatter maps M0 through M*k*. S*k* will be referred to as the *k*-th scatter sum. Note that S0=M0. Figure 8 shows the third scatter sum for the function CSC.

The algorithm for finding an optimal path is as follows: beginning at your goal, follow a path of strictly increasing elements of S*n* until you reach your starting position, choosing the most rapidly increasing path if more than one exists. Since all the possible locations in M*k* are in M*k*+1, for all *k*, the more quickly a location is reached from the starting point, the higher its value will be in each scatter sum.

For example, if the clear terrain square (4,7) was your goal, you would use the third scatter sum, S3, which is in figure 8. Following the movement restrictions imposed by the city function, you will consider only those locations given by the scatter of the current location to determine the next location on your path. Thus, you will choose your next location from the squares (4,8), (4,6), (5,7) and (3,7).

Square (3,7) will be chosen, since it has the maximum value in S3. In the same manner, squares (3,6) and (3,5) will be chosen so that your optimal path from starting point to goal is (3,5) to (3,6) to (3,7) to (4,7). In the same manner, you can find that the optimal path from (3,5) to (2,4) is by way of (2,5).

When you try to find the optimal path and there are, at some point between the goal and start, two or more possible locations from which to choose, you can randomly choose any one of them with equal success. This algorithm, therefore, will find *an* optimal path, but not necessarily the only such path.

In Part 1 I have discussed some general terrain problems and demonstrated a few solutions using a rectangular grid. This method is very easy to implement with two-dimensional boolean arrays and lends itself well to most of the problems that will be encountered. One notable exception, however, is the conflict simulation or "war game." These games are usually played on terrain maps of a battlefield, upon which a grid of hexagons is superimposed.

This hexagonal grid (or hex grid) resembles a honeycomb. It eliminates the need for two different metrics, since there are no diagonals, but it requires the definition of a new system of coordinates.

In Part 2 I shall define this coordinate system, a distance function, and a scatter function. I shall also discuss the representation of specific terrain-related game features such as directional terrain (roads and bridges) and "no-exit" terrain (zones-of-control). ■

BYTE News . . . .

VOICE-CONTROLLED CONSUMER PRODUCTS: At a recent electronics show in Japan, several Japanese manufacturers demonstrated voice-response and voice-activation of many consumer products. Sanyo, Toshiba, Sharp, Sony, Hitachi, and Matsushita demonstrated a wide variety of consumer products that respond to oral commands. Using microprocessor-controlled speech analyzers and synthesizers, the processors controlled television channel selection, volume and color control, and operated video games and clocks. Some units talked back to confirm user commands.

It is expected that many of these products will be commercially available in a year or two. Present technology allows registration of up to three persons in the voice-recognition circuit. Manufacturers agree that the voice recognition is not 100% perfect, but that it will be in time.

SOME HOME COMPUTERS FAIL FCC RFI SPECS: The Federal Communications Commission (FCC) has released the results of their tests of personal computer systems for radio-frequency interference (RFI). RFI has become an increasing problem to television and FM radio reception, similar to the citizen's band radio interference problem several years ago. The FCC has proposed as a standard a radiation limit of 100 microvolts per meter at a 3-meter distance.

Early last year the FCC tested the Radio Shack, Apple, Heath, Texas Instruments (TI), Commodore PET, and Southwest Technical Products personal computers. Only the Texas Instruments and Commodore systems met the specification. Atari had submitted and passed the specification earlier.

The standard goes into effect July 1, 1980, and all manufacturers have declared their intention to make necessary modifications to assure compliance with the specifications.

CENTRONICS REVEALS NEW PRINTING METHOD: In a press conference held on November 13, 1979, Centronics Data Corp of Hudson, New Hampshire, demonstrated a new method of printing on paper. A single stylus driven by voice coils through a parallelogram flexure mechanism presses a carbon ribbon against paper to form characters in almost the same way as people write using pens and pencils. Character fonts are switched by changing the controlling software; an almost infinite variety of symbols may be produced, including mathematical, Greek, Chinese, Cyrillic, and Arabic character sets. The prototype Quietwriter typewriter devices print with excellent quality at a speed of 17 cps for English-language character sets. Products using the Quietwriter mechanism may be sold beginning about the third quarter of 1981.

NEW LISP SYSTEM: The LISP Co (T.(L.C)) of Los Gatos, California, has completed their first version of LISP for the Z80. It is a dialect of the MIT LISP-Machine LISP, complete with strings, I/O streams, Muddle's parameter-description mechanism, and comprehensive documentation. This version was done for a major personal computer manufacturer; (T.(L.C)) will soon announce their own version that will include hardware to support the LISP programming environment.

HOBBYIST ELECTRONIC MAIL SYSTEM FORMING: Hobbyists are setting up a low-cost mail system using their microcomputers. This is possible using a $12 software package from the Personal Computer Network (PCNET) committee. With it, a personal computer owner can set up his machine to automatically dial another system or systems at a preset time (usually late at night), deliver messages, and return a status report (delivered or not delivered).

Hobbyists are also setting up dial-in, free-access message systems for discussion purposes using the FORUM-80 software and Radio Shack TRS-80s. Three forums are already in operation: forums devoted to tracing family histories (in Fairfax, Virginia), information on engineering applications of microcomputers (Olathe, Kansas), and applications of microcomputers for the handicapped (Memphis, Tennessee). For more information on these applications, contact Jon Tara, c/o SEMCO, POB 9578, Detroit MI 48202.

COMPUTER COMPANIES GO INTO RETAILING: The latest computer stores are those set up by Digital Equipment Corp (DEC), IBM, and NCR. Following the innovative experiences in computer retailing established by Tandy Corp and independent stores, the traditional computer manufacturers have decided to meet the challenge head on. DEC already has in operation almost twenty "computer stores" where customers can sample the DEC small computers. However, the stores have no inventory and purchases are shipped from a distribution center.

IBM now stocks their 5110 small business systems at fifty centers where a purchaser can get a system on a cash-and-carry basis. These centers were originally opened to demonstrate and train users, and then the retail operation was added. A typical system sells for $16,000.

NCR has opened two pilot stores in Cincinnati to sell cash registers and small computers in the $15,000 price range. Data General is selling its MicroNOVA system through fifty independent dealers, and Texas Instruments is beginning computer demonstrations in its San Francisco store.

With the cost of small business computer systems decreasing, the profit margin is no longer enough to support the high-cost selling techniques of large computer systems.

MOTOROLA, TANDY AND WESTERN UNION INTRODUCE "GREEN THUMB" SYSTEMS: Sponsored by a grant from the US Department of Agriculture, Motorola and Western Union will set up an experimental agricultural video-telephone information system known as Project Green Thumb. Tandy Corp will manufacture the terminals to be located in 200 farm homes in Kentucky. Farmers, via telephone lines, will be able to access weather, market, and agriculture data from remote computers.

RANDOM NEWS: Atari has filed an appeal with the Federal Communications Commission (FCC) to stay the decision (reported in last month's BYTE News) in which the FCC granted Texas Instruments a waiver on permissible interference standards for personal computers. Atari feels that if other companies can pass the specification, then the TI request should not have been granted . . . . Texas Instruments will soon have competition in the voice synthesis area. National Semiconductor Corp and ITT Semiconductor are both showing samples of their new synthesizer parts. These integrated circuits are aimed at low-price consumer applications such as talking clocks, telephone-answering equipment and automobile warning devices . . . . Texas Instruments has introduced four new terminals that have dual-matrix print heads. The head prints two characters with each pass across the page enabling the unit to print 120 characters per second . . . . MIT (Massachusetts Insitute of Technology) has received a development contract worth several million dollars from Heath Co and Exxon Enterprises. The contract calls for the MIT Computer Science Laboratory to develop an advanced cartridge-disk-based 16-bit microcomputer system for use in office automation. Although initial plans called for MIT to use Zilog's 16-bit microprocessor, it is reported that they have switched to the Motorola 68000 to use memory more efficiently. Both Heath and Exxon will have nonexclusive manufacturing rights, and Exxon will have exclusive software rights . . . . Chuck Peddle, the developer of the 6502 microprocessor, the KIM-1, and PET computers, has a new product. It is the Commodore 4500 4-bit microprocessor. It represents a radical departure from the 6502 architecture . . . . Researchers at Bell Labs announced the development of an improved electrochromic display using iridium. It consumes less power and could be cheaper to produce than light-emitting diode and liquid-crystal type displays. It does not have to be energized continuously and is pulsed to turn on and off.

APOLOGY DUE: In the September 1979 BYTE News column, I reported on 16-bit 8086 processor boards for S-100 systems. I regret that I omitted mention of a company that has been making such a board since December 1978. The company is Tecmar Inc, 23414 Greenlawn Ave, Cleveland OH 44122. They sell a complete line of S-100 boards to make up a complete system.

RANDOM RUMORS: Apple Computer will soon introduce the Apple III, and it is rumored that it will not use the 6502 microprocessor. Apple is keeping a tight lid on their plans (bit-slice, perhaps?) for this unit. . . .Digital Research, the firm that developed CP/M, the most popular disk operating system for microcomputer systems, will soon announce a version of CP/M for the Intel 8086 16-bit microprocessor, which will include an assembler program. . . .IMI (International Memories Inc) of Cupertino, California, the first company to ship 8-inch, Winchester-technology, hard disk drives, is rumored to be planning to show a 5¼-inch, 3-megabyte Winchester drive at the 1980 National Computer Conference in June. Rumor is that there will be at least one other such drive shown at the NCC. . . .

MAIL: I receive a large number of letters each month, as a result of this column. If you wish a response please include a stamped, self-addressed envelope.

Sol Libes
Amateur Computer Group of New Jersey (ACG-NJ)
1776 Raritan Rd
Scotch Plains NJ 07076

SYNCHRO-SOUND

A Computer-Controlled Light Dimmer

Part 2: Implementation

John H Gibson
Physics Department
Alma College
Alma MI 48801

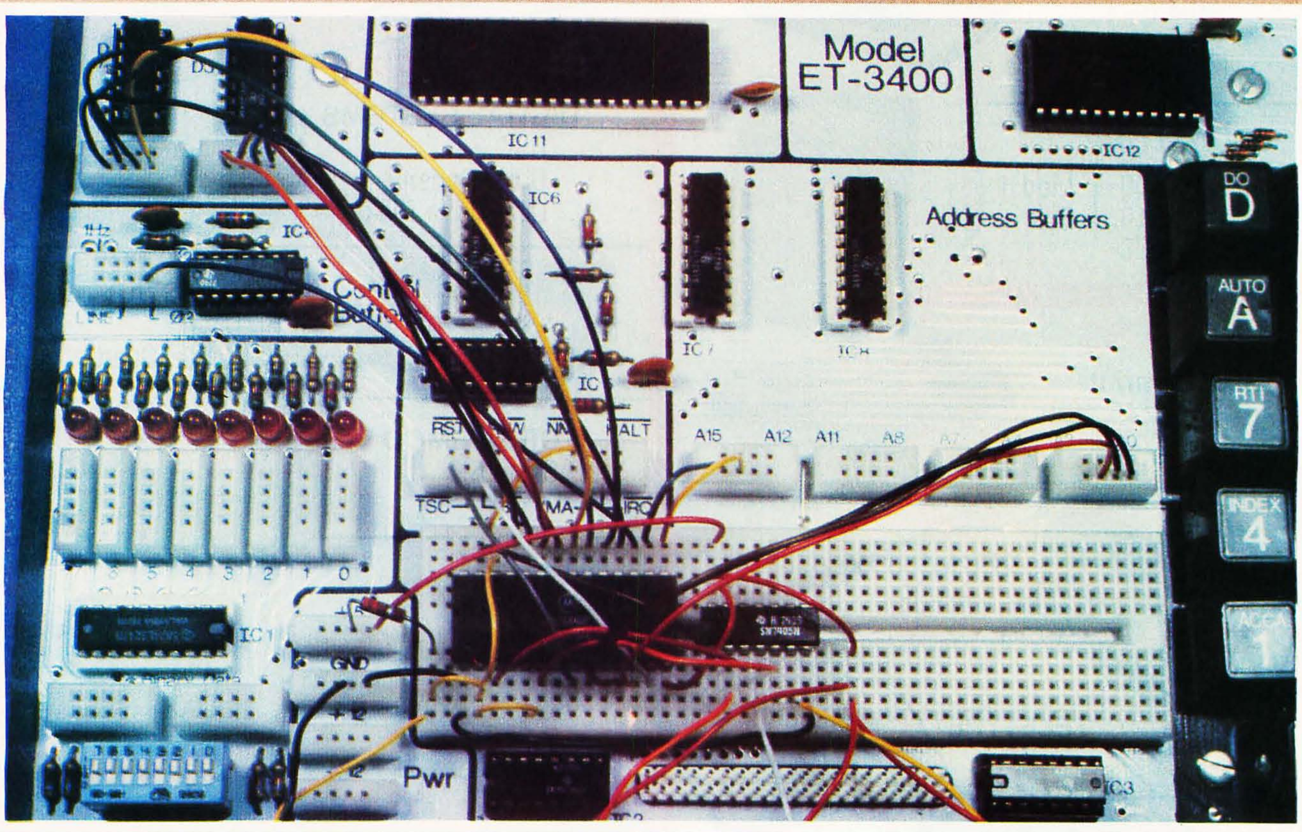


Photo 3: *Close-up view of the Heathkit ET-3400 microprocessor trainer wired for use with the demonstration program. The ET-3400 programmable timing module is connected to the trainer's data bus via the eight wires from the left corner of the picture. The synchronizing signal is transmitted over the yellow-black twisted pair at the bottom of the picture. The red-orange, red-white, and red-yellow twisted pairs carry the output trigger pulses to the three AC phase controls.*

The numbering of the photos, figures, and tables is continued from part 1 of this article, January 1980 BYTE, page 56.

In part 1 is an examination of the basic principles and techniques for achieving proportional AC phase control with a microcomputer and a programmable timer. I would now like to present a completely worked-out demonstration program designed to run on a Heathkit ET-3400 microprocessor trainer. This demonstration program will operate three lamp circuits, giving you keyboard control over the lamps that are to be faded on and off.

In addition to the ET-3400 trainer, you will need an MC6840 programmable timer module, a 7405 hex inverter (open collector), a synchronizer (from figure 5 in part 1), and three AC phase controls (each from the circuit of figure 9 in part 1).

Here is a step-by-step procedure for making the demonstration program work:

1) Plug the MC6840 and the 7405 integrated circuits into the ET-3400 trainer's breadboard socket.

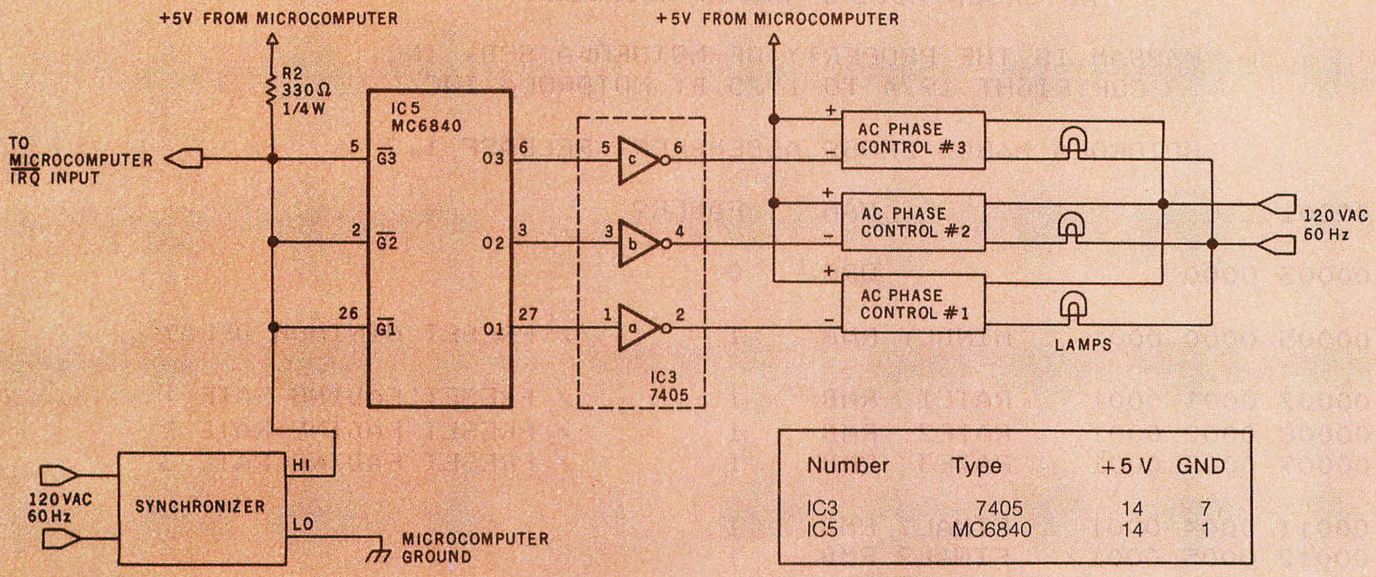


Figure 10: *Wiring diagram for proportional power control of three AC lamp circuits. Connections between the MC6840 programmable timer and the ET-3400 microprocessor trainer have been omitted for clarity.*

2) Make the connections between the MC6840 and the ET-3400 trainer as shown in table 2.
3) Wire the circuit shown in figure 10.
4) Load the FADER2 program in listing 1 beginning at location hexadecimal 0100.
5) Memory location 0000 stores a minimum delay number for all lamps. If you want the lamps to reach maximum brightness, it should be preset to 00.
6) Fading rates for the three lamps should be preset in memory locations 0001, 0002, and 0003. Setting each of these rate values to hexadecimal FF will cause each lamp to go from complete darkness to full brightness in about 2 seconds. At the opposite extreme, setting each rate value to 01 will cause this change to take 9 minutes.
7) Location hexadecimal 017F contains the output-pulse-width value hexadecimal 1E that was computed in part 1 of this article. This pulse width was computed for a microprocessor clock frequency of 1 MHz. If your system's clock frequency is different, you will have to recompute this pulse width.

A pulse width that is too short will not permit the lamps to darken completely; a pulse width that is too long will cause the lamps to flicker or flash back on at full brightness just when you expect them to be completely dark.

8) The program (listing 1, p. 74) begins execution at location hexadecimal 0100, initializing all variable locations. With the program running, pushing keys 0 thru 7 will fade the lamps on and off in different combinations, according to the binary value of the keys pressed. The lamps' changing values will appear on the ET-3400's six seven-segment readouts.
9) You can stop the program without turning off the lamps by pushing the 9 (break) key. With the program stopped, you may examine and change registers, all without affecting the lamps. You may then restart the program at location hexadecimal 0110, which retains previous values in the variable locations.

This demonstration program should be enough to fire your imagination to think of your own applications for this lamp control technique. I will be interested in hearing about programs and applications developed by BYTE readers.

6840	6840 Pin Numbers	ET-3400
V_{ss}	1	GND
V_{cc}	14	+5 V
$\overline{RESET}$	8	$\overline{RST}$
$\overline{IRQ}$	9	no connection
RS0	10	A0
RS1	11	A1
RS2	12	A2
$R/\overline{W}$	13	$R/\overline{W}$
$\overline{CS0}$	15	A14
CS1	16	A15
Enable	17	$\phi 2$
D0	25	D0
D1	24	D1
D2	23	D2
D3	22	D3
D4	21	D4
D5	20	D5
D6	19	D6
D7	18	D7

Table 2: *Connections to be made between the Heath ET-3400 microprocessor trainer and the MC6840 programmable timer.*

Author's Note

I am indebted to Professor Kameswara Rao, of National Semiconductor, Santa Clara CA, for his advice and technical support. This lamp control program was developed and tested in his electronics laboratory at Western Michigan University with the aid of a Motorola M6800 cross-assembler resident on Western's PDP-10 computer.

Listing 1: *FADER2, a program written in assembler language for the Motorola M6800 processor to control the light dimmer.*

```
                MOTOROLA M68SAM CROSS-ASSMBLER

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          MOTOROLA M6800 CROSS ASSEMBLER, RELEASE 1.2

                        NAM    FADER2

      0000              ORG    0

      0000 0001  MINDLY RMB    1          / PRESET MINIMUM DELAY

      0001 0001  RATE1  RMB    1          / PRESET FADING RATE 1
      0002 0001  RATE2  RMB    1          / PRESET FADING RATE 2
      0003 0001  RATE3  RMB    1          / PRESET FADING RATE 3

      0004 0001  FINAL1 RMB    1
      0005 0001  FINAL2 RMB    1
      0006 0001  FINAL3 RMB    1

      0007 0001  DELAY1 RMB    1
      0008 0001  DELAY2 RMB    1
      0009 0001  DELAY3 RMB    1

      000A 0001  INTER1 RMB    1
      000B 0001  INTER2 RMB    1
      000C 0001  INTER3 RMB    1

           00F7  UIRQ   EQU    $00F7      / MONITOR VECTORS HERE ON IRQ


                 * ADDRESSES IN PROGRAMMABLE TIMING MODULE

           8000  CR1    EQU    $8000
           8001  CR2    EQU    CR1+1
           8000  CR3    EQU    CR1

           8002  M1     EQU    CR1+2      / MSB OF LATCH 1
           8003  L1     EQU    CR1+3      / LSB OF LATCH 1

           8004  M2     EQU    CR1+4      / MSB OF LATCH 2
           8005  L2     EQU    CR1+5      / LSB OF LATCH 2

           8006  M3     EQU    CR1+6      / MSB OF LATCH 3
           8007  L3     EQU    CR1+7      / LSB OF LATCH 3


                 * THESE ET-3400 MONITOR SUBROUTINES ARE USED

           FC00  RESET  EQU    $FC00      / RETURN TO MONITOR
           FDF4  INCH   EQU    $FDF4      / INPUT CHAR FROM KEYBOARD
           FCBC  REDIS  EQU    $FCBC      / RESET DISPLAY TO 1ST LED
           FD7B  DSPLAY EQU    $FD7B      / DISPLAY ROUTINE

                 * MAKE A COLD START FROM THIS ADDRESS - $0100
```

Listing 1 continued on page 76

The Source for 6800/6809 Software

Technical Systems Consultants, Inc, is The Source for your 6800/6809 systems software needs. From FLEX™, the standard disk operating system of the 680X family, to Sort/Merge, your systems requirements can be filled with the highest quality software in the industry. Nowhere else can you find such variety from a single source. Here are some of the most popular:

Program Name	*6800*	*6809*
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FLEX for SSB	**90**	**90**
Extended BASIC	**100**	**100**
Extended BASIC Precompiler	**50**	**50**
BASIC	**65**	**65**
BASIC Precompiler	**40**	**40**
FLEX Sort/Merge	**75**	**75**
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These packages are available on either 8" or 5" soft-sectored FLEX diskettes (5" 6800 is FLEX 2.0). Price includes user's manual and object code diskette. Certain programs are available on cassette. Contact Technical Systems Consultants for pricing. All orders should include 3 percent for postage and handling (8 percent on foreign orders). Master Charge and Visa are welcome.

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Box 2574, West Lafayette, IN 47906
(317) 463-2502

on inquiry card.

Listing 1 continued:

```
0100                         ORG    $100

                      * INITIALIZE DELAYS SO ALL LAMPS ARE OFF

0100 86 FF    CLDSTR LDA A  #$FF       / MAXIMUM DELAY VALUE
0102 CE 0004         LDX    #FINAL1    / INITIALIZE POINTER

0105 A7 00    INITIA STA A  0,X        / STORE #$FF HERE
0107 08              INX               / POINT TO NEXT VARIABLE
0108 8C 000D         CPX    #INTER3+1   / LAST VARIABLE?
010B 26 F8           BNE    INITIA     / RETURN IF NOT DONE

010D 01              NOP
010E 01              NOP
010F 01              NOP

                      * MAKE A WARM START FROM THIS ADDRESS - $0110

0110 0F       WRMSTR SEI               / MASK IRQ WHILE INITIALIZING

                      * THESE STEPS CONFIGURE THE TIMERS FOR SINGLE-SHOT
                      * OPERATION WITH TURN-ON DELAY M(L+1)T AND OUTPUT
                      * PULSE WIDTH LT.

0111 86 B6           LDA A  #$B6       / CONTROL WORD FOR CR3, CR1
0113 C6 B7           LDA B  #$B7       / CONTROL WORD FOR CR2

0115 B7 8000         STA A  CR3        / CONFIGURE TIMER 3
0118 F7 8001         STA B  CR2        / CONFIGURE TIMER 2
011B B7 8000         STA A  CR1        / CONFIGURE TIMER 1

                      * ON IRQ, THE ET-3400 VECTORS TO LOCATION
                      * UIRQ.  WE MUST PROVIDE A JUMP INSTRUCTION
                      * AND A VECTOR TO TRANSFER TO OUR PROGRAM'S
                      * IRQ SERVICE ROUTINE AT LOCATION #CYCLE.

011E 86 7E           LDA A  #$7E       / LDA A WITH JUMP COMMAND
0120 97 F7           STA A  UIRQ       / STORE JUMP COMMAND AT UIRQ

0122 CE 0137         LDX    #CYCLE     / JUMP TO THIS LOCATION
0125 DF F8           STX    UIRQ+1     / STORE #CYCLE AT UIRQ VECTOR

0127 0E              CLI               / CLEAR IRQ MASK

                      * MAIN PROGRAM LOOP

0128 BD FDF4 KEY     JSR    INCH       / GET HEX VALUE OF KEY PUSHED

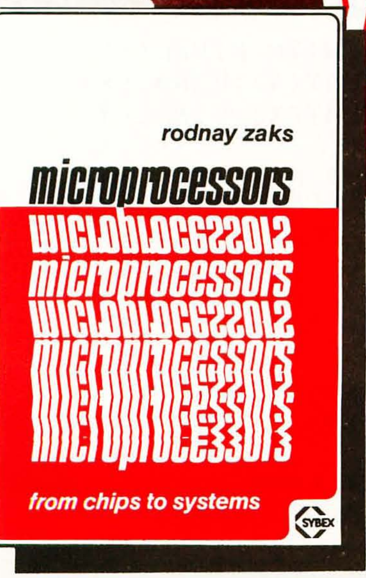
012B 81 09           CMP A  #$09       / IS IT "BREAK" KEY?
012D 26 04           BNE    CONT       / BRANCH IF NOT "BREAK"

012F 0F              SEI               / SET IRQ MASK
0130 7E FC00         JMP    RESET      / GO TO ET-3400 MONITOR RESET
```

Listing 1 continued on page 78

worldwide best selling textbook





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This bestseller on microprocessors offers a basic introduction to microcomputer systems. The step-by-step presentation assumes no prior knowledge of the subject. The author covers all aspects of microprocessing, from the basic concepts to advanced interfacing techniques, guiding the reader from Fundamental Concepts, through Systems Components and Interfacing, all the way to Systems Development. Based on the author's extensive experience in research and education. Used by schools and universities worldwide.

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Listing 1 continued:

```
0133 8D 09    CONT   BSR    NEWFN     / SET NEW FINAL VALUES
0135 20 F1           BRA    KEY       / GET NEXT CLOSED KEY VALUE

                     * IRQ INTERRUPT SUBROUTINE

0137 8D 1E    CYCLE  BSR    CHANGE    / CHANGE DELAY VALUES
0139 8D 3E           BSR    LOAD      / LOAD TIMERS WITH NEW DELAYS
013B 8D 54           BSR    SHOW      / DISPLAY DELAY VALUES
013D 3B              RTI

                     * SUBROUTINE TO CHANGE FINAL VALUES

013E 81 07    NEWFN  CMP A  #$07      / VALID HEX VALUE?
0140 22 14           BHI    NEWFN4    / BRANCH IF NOT VALID

0142 CE 0004         LDX    #FINAL1    / POINT TO FINAL1

0145 46       NEWFN1 ROR A            / SHIFT LAMP(X) BIT INTO C
0146 24 04           BCC    NEWFN2    / BRANCH TO DIM LAMP

0148 D6 00           LDA B  MINDLY    / LDA B WITH MIN DELAY
014A 20 02           BRA    NEWFN3

014C C6 FF    NEWFN2 LDA B  #$FF      / LDA B WITH MAX DELAY

014E E7 00    NEWFN3 STA B  0,X       / STA B FINAL(X)

0150 08              INX              / POINT TO NEXT LAMP
0151 8C 0007         CPX    #FINAL3+1   / LAST LAMP DONE?
0154 26 EF           BNE    NEWFN1    / RETURN IF NOT DONE

0156 39       NEWFN4 RTS

                     * ROUTINE FOR CHANGING DELAY NUMBERS

0157 CE 0001  CHANGE LDX    #RATE1    / POINT TO LAMP 1

015A E6 09    CHNG1  LDA B  9,X       / LDA B INTER(X)
015C A6 06           LDA A  6,X       / LDA A DELAY(X)

015E A1 03           CMP A  3,X       / CMP DELAY(X) WITH FINAL(X)
0160 22 08           BHI    BRITER    / BRANCH IF DELAY(X)>FINAL(X)
0162 27 0A           BEQ    RESTOR    / BRANCH IF DELAY(X)=FINAL(X)

0164 EB 00    DIMMER ADD B  0,X       / B = INTER(X) + RATE(X)
0166 89 00           ADC A  #$00      / A = DELAY(X) + CARRY
0168 20 04           BRA    RESTOR

016A E0 00    BRITER SUB B  0,X       / B = INTER(X) - RATE(X)
016C 82 00           SBC A  #$00      / A = DELAY(X) - BORROW

016E E7 09    RESTOR STA B  9,X       / STA B INTER(X)
0170 A7 06           STA A  6,X       / STA A DELAY(X)

0172 08              INX              / POINT TO NEXT LAMP
0173 8C 0004         CPX    #RATE3+1   / DONE WITH ALL 3 LAMPS?
```

Listing 1 continued on page 80

MicroNET

It's off and running. And delivering as promised.

What is MicroNET?

It is the personal computing service of CompuServe, Incorporated. CompuServe is a nationwide commercial time sharing computer network with large-scale mainframes. MicroNET allows the personal computer user access to CompuServe's large computers, software and disc storage during off-peak hours (from 6 PM to 5 AM weekdays, all day on Saturdays, Sundays and most holidays).

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- **NEW!** MicroQUOTE, a security information system for corporate stocks and public debt.
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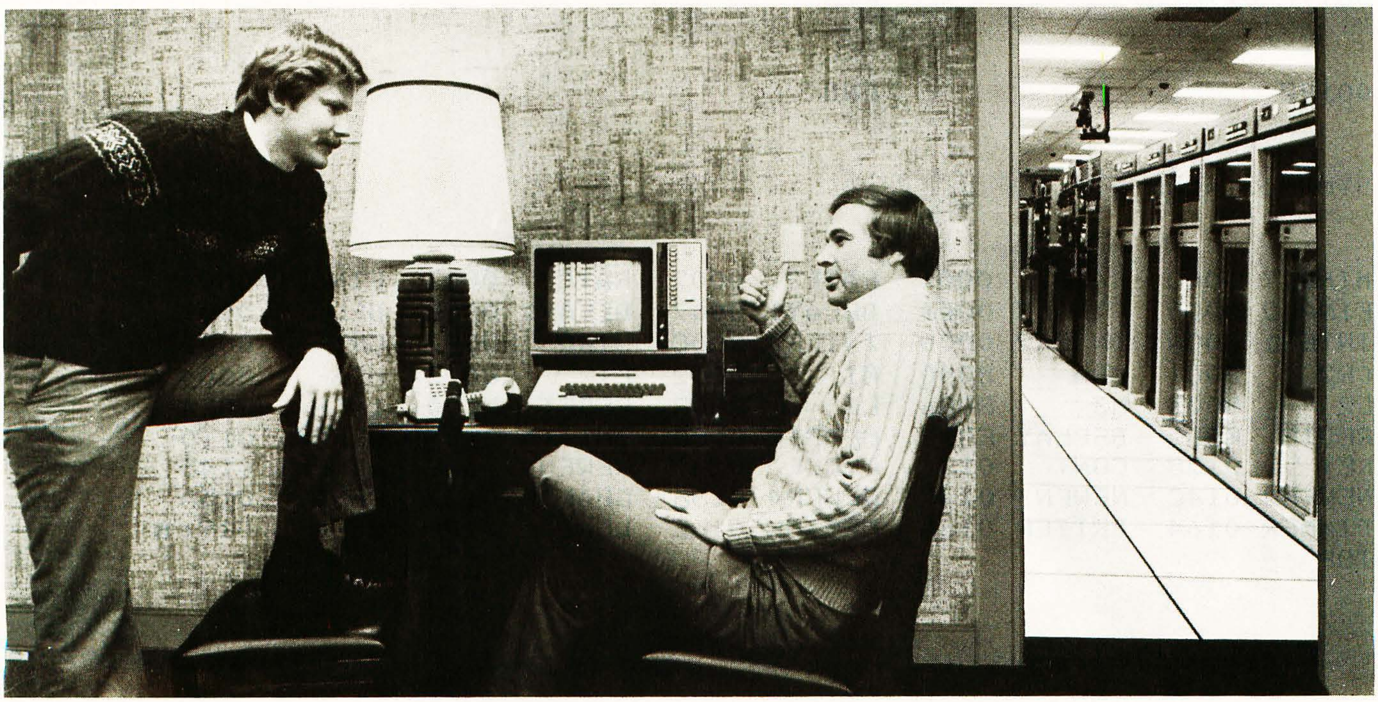
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CompuServe
Personal Computing Division
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MicroNET is available via local phone calls in the following cities: Akron, Atlanta, Boston, Canton, Chicago, Cincinnati, Cleveland, Columbus, Dallas, Dayton, Denver, Detroit, Houston, Indianapolis, Los Angeles, Louisville, Memphis, West Caldwell (NJ), New York, Philadelphia, Pittsburgh, San Francisco, Stamford (CT), St. Louis, Toledo, Tucson and Washington, D.C.

Access to the MicroNET service is available in 153 other cities for an additional charge of $4.00 per hour.



"... but the really impressive stuff is in the back room."

Listing 1 continued:

```
0176 26 E2                 BNE    CHNG1       / RETURN TO DO NEXT LAMP

0178 39                    RTS

                       * THIS ROUTINE LOADS THE TIMER LATCHES

0179 CE 8002 LOAD          LDX    #M1         / POINT TO M1

017C 96 07                 LDA A  DELAY1
017E C6 1E                 LDA B  #$1E        / OUTPUT PULSE WIDTH
0180 A7 00                 STA A  0,X         / LOAD M1 WITH DELAY1
0182 E7 01                 STA B  1,X         / LOAD L1 WITH PULSE WIDTH

0184 96 08                 LDA A  DELAY2
0186 A7 02                 STA A  2,X         / LOAD M2 WITH DELAY2
0188 E7 03                 STA B  3,X         / LOAD L2 WITH PULSE WIDTH

018A 96 09                 LDA A  DELAY3
018C A7 04                 STA A  4,X         / LOAD M3 WITH DELAY3
018E E7 05                 STA B  5,X         / LOAD L3 WITH PULSE WIDTH

0190 39                    RTS

                   * THIS ROUTINE SHOWS THE THREE DELAY VALUES ON
                   * THE ET-3400'S SIX 7-SEGMENT READOUTS.

0191 BD FCBC SHOW          JSR    REDIS       / RESET DISPLAY TO 1ST LED
0194 CE 0007               LDX    #DELAY1     / START DISPLAY WITH DELAY1
0197 C6 03                 LDA B  #03         / DISPLAY 3 BYTES
0199 BD FD7B               JSR    DSPLAY      / DISPLAY DELAY1, 2 AND 3

019C 39                    RTS

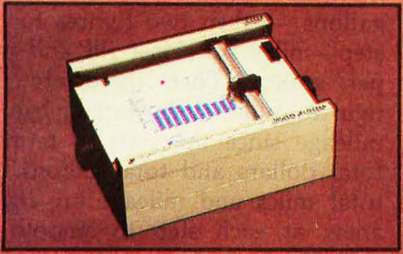
                           END

SYMBOL TABLE

MINDLY 0000  RATE1  0001  RATE2  0002  RATE3  0003  FINAL1 0004
FINAL2 0005  FINAL3 0006  DELAY1 0007  DELAY2 0008  DELAY3 0009
INTER1 000A  INTER2 000B  INTER3 000C  UIRQ   00F7  CR1    8000
CR2    8001  CR3    8000  M1     8002  L1     8003  M2     8004
L2     8005  M3     8006  L3     8007  RESET  FC00  INCH   FDF4
REDIS  FCBC  DSPLAY FD7B  CLDSTR 0100  INITIA 0105  WRMSTR 0110
KEY    0128  CONT   0133  CYCLE  0137  NEWFN  013E  NEWFN1 0145
NEWFN2 014C  NEWFN3 014E  NEWFN4 0156  CHANGE 0157  CHNG1  015A
DIMMER 0164  BRITER 016A  RESTOR 016E  LOAD   0179  SHOW   0191
STOP --
```

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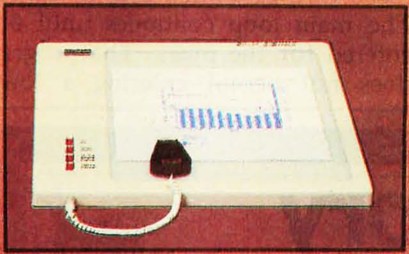
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Gasuse

Mike R Firth, 4712 Northway Dr,
Dallas TX 75106

Gasuse is a program I wrote to use facts I record in a notebook in my car to produce useful information. I note the mileage of my car, the cost of the gas, and usually the gallons and dollars of the purchase along with the state of purchase and date (for tax purposes). Aside from the special features noted below, the program in listing 1 consists of the initialization routine (lines 1010 thru 1084), the main loop (1100 thru 1900), and routines to allow for missing information (2000 thru 2190) and printer output. The main loop continues until 0 is entered for the miles. The program does not permit entering a lower mileage than the last mileage reading. The missing information section will permit computations if two of the three items— price, gallons, cost— are known.

The information printed out includes the entered (or calculated) numbers—miles at purchase, dollars, gallons — then two figures for this step—miles since last fill and miles per gallon. Then there are total figures—miles since start of trip and mileage since the start in terms of total dollars and total gallons. The total miles and mileage are figured anew at each step to smooth out errors.

Notes on odd items: lines 40 and 50 save retyping the commands used on the Wang for disk storage. U$ contains the character to move the cursor up one line. This results in the display being solid information, neatly arranged, with data entered on the bottom lines. The Select Print statements after line 8100 are the means of assigning the printed output. Only one device can be selected at a time, where 005 is the video terminal and 215 is the fast printer. Lines 9400 thru 9406 are special functions that relate to special keys on the terminal and permit controlled listing of the program. Wang uses % for image statements, where most BASICS use : in my experience.

Table 1 is an example output from listing 1. (See table 1 and listing 1 on page 124.) Please note that while two of the segment mileage figures vary considerably (17.9 and 40.1), the average mileage stays in the mid-twenties. One reason that segment mileage will vary is that the tank is not filled to the same point each time. If 10 gallons are used in 250 miles, but only 5 are purchased the program will give twice the mileage for that segment. However, when one has to fill-up with 10 gallons after only 125 miles, the mileage will drop.

Note that the totals are run up each time the program is run, which represent a page in your notebook—all the gas purchased on a trip or a month's driving. To add to a list, simply take the old list's starting mileage and the final totals as the first entry, (see table 1 for example).

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All Microsoft prices are discounted!

MICROSOFT

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  HDBS-Z80 version .... **$250/$35**
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  8080 Version available at $75. extra.

NOTE → Z80 version requires 20K RAM. 8080 version requires 24K RAM. (Memory requirements are additional to CP/M and application program.)
When ordering HDBS or MDBS please specify if the version required is for 1) Microsoft L80 i.e. FORTRAN-80, COBOL-80, BASIC COMPILER, 2) MBASIC 4. XX, or 3) BASIC-80 5.0.

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EIDOS SYSTEMS

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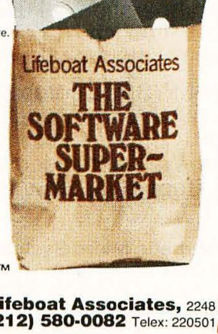
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Listing 1: *Gasuse program for determining mileage, gas efficiency, and keeping track of gas expenses.*

```
10    REM PROGRAM GAS TO FIGURE MILEAGE
40    REM SCRATCH F "GASUSE"
50    REM SAVE DC F ("GASUSE") "GASUSE"
110   U$ = HEX(OC)
1010  PRINT " I COMPUTE AND DISPLAY GAS MILEAGE"
1020  PRINT "  ENTER ZERO FOR UNKNOWN FIGURES, I WILL TRY"
1030  PRINT "  ENTER ZERO FOR MILES TO STOP"
1032  PRINT
1035  PRINT " ENTER  1. FOR SCREEN DISPLAY"
1037  PRINT "          2. FOR PRINTER OUTPUT"
1039  INPUT P9
1040  PRINT
1050  PRINT "STARTING MILES";
1060  INPUT MO
1070  M7 = MO
1075  IF P9 = 2 THEN 8100
1080  PRINTUSING 1081
1081  %   COST  DISTANCE  TOTAL  AVE   TOTAL  TOTAL
1082  PRINTUSING 1083
1083  %MILES  GAL  MILEAGE  MILES  MILEAGE  COST  GAL
1084  PRINT
1100  PRINT U$; "NEXT MILES";
1110  INPUT M1
1115  IF M1 = 0 THEN 1900
1120  IF M1 > M7 THEN 1130
1124  PRINT U$;" THIS MILES LESS THAN LAST, OR SAME"
1126  GOTO 1100
1130  PRINT U$;"   GALLONS";
1140  INPUT G1
1160  PRINT U1;"      DOLLARS";
1170  INPUT D1
1190  IF G1 = 0 THEN 2000
1195  IF D1 = 0 THEN 2100
1200  REM
1210  M8 = M1-MO
1220  D8 = D8 + D1
1230  G8 = G8 + G1
1245  IF P9 = 2 THEN 8150
1248  PRINT U$;
1250  PRINTUSING 1252,M1,D1,G1,M1-M7,(M1-M7)/G1,M1-M0;M8/G8,D8,G8
1252  %###### $##.## ##.# ### ##.# ##### ##.# $###.## ###.#
1255  PRINT
1260  M7 = M1
1290  GOTO 1100
1900  STOP
2000  PRINT U$; " GALLONS ENTERED AS ZERO, ENTER CENTS/GALLON";
2010  INPUT C1
2020  IF D1 = 0 THEN 2080
2030  G1 = D1/(C1/100)
2050  GOTO 1200
2080  PRINT U$; " DOLLARS ALSO ZERO, NO CALCULATION POSSIBLE";
2090  GOTO 1100
2100  PRINT U$; " DOLLARS ENTERED AS ZERO, ENTER CENTS/GALLON";
2110  INPUT C1
2120  D1  =  G1*(C1/100)
2130  IF D1 = 0 THEN 2180
2150  GOTO 1200
2180  PRINT U$;" CALCULATION RESULT IS ZERO; REENTER "
2190  GOTO 1100
8100  SELECT PRINT 215(80)
8110  PRINTUSING 1081
8111  PRINTUSING 1083
8115  SELECT PRINT 005(64)
8120  GOTO 1084
8150  SELECT PRINT 215(84)
8160  PRINTUSING 1252,M1,D1,G1,M1-M7, (M1-M7)/G1,M1-M0;M8/G8,D8,G8
8170  SELECT PRINT 005(64)
8180  PRINT U$;TAB(64)
8190  GOTO 1260
9400  DEFFN'0 "LISTS"
9404  DEFFN'1 ",9999"
9406  DEFFN'2 "000,9999"
```

MILES	COST	GAL	DISTANCE	MILEAGE	TOTAL MILES	AVE MILEAGE	TOTAL COST	TOTAL GAL
1202	$4.19	7.5	201	26.8	201	26.8	$4.19	7.5
1453	$5.75	10.1	251	24.8	452	25.6	$9.94	17.6
1604	$2.59	5.0	151	30.2	603	26.6	$12.53	22.6
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1995	$3.95	6.9	280	40.1	994	27.7	$19.93	35.7

Table 1: *Sample output from listing 1. To determine accurate gas usage take an average over several results.*



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Programming Quickies

String Comparator for Horizon

Richard W Lindberg, 9302 Mayrene Dr, Garden Grove CA 92641

As a recent purchaser of a personal computer, and an even more recent subscriber to BYTE, I look for programming articles to help expand the horizon of my Horizon. I scanned the September 1979 issue as soon as it arrived, and was intrigued by the article "A Similarity Comparator for Strings," by T C O'Haver on page 58. Realizing changes would be necessary, I immediately set out to translate it to run in North Star BASIC.

The first change required was the replacement of the string operator MID$(A$,I,1) with A$(I,I) in statements 130, 140, 230, and 240. (Note that North Star also allows the implied LET and the use of ! for PRINT.) The next change was the addition of a DIMension statement to allow strings greater than 10 characters in length. Then when trying to compare two strings of different length, the computer threw me out! This necessitated having enough blanks in the shorter string to match the length of the longer one. To accomplish this, strings A$ and B$ were set to 64 blanks by the dimension statement, and temporary strings A1$ and B1$ were used to read in the input string data and compute the lengths A and B. A1$ was then placed in the first A characters of A$, and B1$ in the first B characters of B$, leaving the remaining characters blank. Blank string Z$ is used to reset B$ to blanks before testing a new string, otherwise there would be unwanted characters left in B$ if the previous string were longer than the new string. This was noticed when I followed O'Haver's test sequence, and found that POO gave a 100% match with POOL, because the previous test string was COOL and the L was still there. So with the addition of line 325, I knocked the L out of it and had the program running. The address strings took many seconds to run.

Listing 1 gives the program as adapted to North Star BASIC Version 5.0, and listing 2 shows a sample run for comparison with the published run. Note that the agreement is quite good except for POOL ROOM, MAIL ROOM, and the long address strings. These differences are possibly due to the addition of the trailing blanks to fill the shorter string. A speedier version would be even more useful, and I am looking forward to the assembly language version — who would like to write it?

Listing 1: *Similarity comparator program in North Star BASIC, adapted from the program by T C O'Haver.*

```
8    DIM A$(64),B$(64),Z$(64),A1$(64),B1$(64)
10   T=0
20   P=3
30   !"FIRST WORD",
40   INPUT A1$
50   A=LEN(A1$)
55   A$(1,A)=A1$
60   !"SECOND WORD",
70   INPUT B1$
75   IF A1$=B1$ THEN !"EXACT MATCH"
80   B=LEN(B1$)
85   B$(1,B)=B1$
90   IF A>B THEN B=A
100  FOR M=1 TO B
110    C=0
120    FOR I=1 TO M
130      K$=A$(B-M+I,B-M+I)
140      L$=B$(I,I)
150      IF K$=L$ THEN C=C+1
160    NEXT I
170    C=C↑P
180    T=T+C
190  NEXT M
200  FOR M=B+1 TO 2*B-1
210    C=0
220    FOR I=1 TO 2*B-M
230      K$=A$(I,I)
240      L$=B$(M-B+I,M-B+I)
250      IF K$=L$ THEN C=C+1
260    NEXT I
270    C=C↑P
280    T=T+C
290  NEXT M
300  S=100*T/B↑P
310  !S,"%"
320  T=0
325  B$=Z$
330  GOTO 70
340  END
```

Listing 2: *Two sample executions of the program in listing 1.*

```
RUN
FIRST WORD ?POOL
SECOND WORD ?POOL
EXACT MATCH
 103.125%
?POOR
 45.3125%
?COOL
 45.3125%
?POO
 45.3125%
?POLO
 28.125%
?LOOP
 18.75%
?PAIL
 12.5%
?POOL ROOM
 20.164609%
?MAIL ROOM
 3.0178326%
?PO/OL
 14.4%
?OOOO
 40.625%

RUN
FIRST WORD ?T.C. O'HAVER 710 HILLSBORO DR. SILVER
SPRING MD.
SECOND WORD ?TOM O'HAVER 710 HILLSBORO DR. SILVER
SPRING MD.
 77.241074%
?R.D. O'HAVER 710 HILLSBOROUGH RD. SILVER SPRINGS FL.
 14.492063% ■
```



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Clubs and Newsletters

Sorcerer User's Group in Ann Arbor MI

The Sorcerer User's Group and their newsletter, *The Sorcerer's Apprentice*, are based in Ann Arbor MI. The group meets once a month at the Newman Computer Exchange and the newsletter is printed every month and a half. The group's object is to spread Sorcerer-related information to all owners and to get as much out of the machine as possible. Contact Dave Bristor, 1530 Washtenaw, Ann Arbor MI 48104.

Computer Group for Medicine and Science

Microcomputers in Medicine and the Sciences Association is an organization devoted to aiding members of the medical and scientific communities gain working knowledge of computers and their uses in research and practical applications. Meetings are accredited seminars covering languages and applications of microcomputers. They meet in the Chemistry Building, Rm 105, University of South Florida, Tampa FL, on the fourth Thursday of the month at 7:30 PM. Their newsletter is called *MIMSA News*.

Software World

Called the *Software World*, this quarterly publication from England contains programs, book reviews, new products, and computer related business items. The subscription rate in the US is $64 a year. The newsletter is one of a series of three software related publications from A P Publications Ltd, 322 St John St, London EC1V 4QH ENGLAND.

Compucolor User's Group

The Canadian Compucolor User's Group meets on the second Wednesday of every month and invites users as well as interested onlookers to join and utilize the program library. For more information, contact House of Computers Inc, 368 Eglinton Ave W, Toronto, Ontario M5N 1A2 CANADA.

Club 1802 Newsletter

Club 1802 is a newsletter published for users of microcomputers which are based upon the 1802 processor. Programs, book and program reviews, want ads, items for sale and letters on related subjects are included. The newsletter is published twelve times a year and current rates are scheduled to be about $10 a year. For more information, contact *Club 1802*, POB 985, Dickinson TX 77539.

Apple Dayton

This Apple II users group alternates their meeting dates between the second Wednesday of odd numbered months and the second Thursday of even numbered months to allow different people to attend at least bi-monthly. Meetings are held at Computer Solutions, 1932 Brown St, Dayton OH, at 7:30 PM. For more information, contact Apple Dayton, Robert W Rennard, 2281 Cobble Stone Ct, Dayton OH 45431.

Sorcerer User's Group Newsletter

The Exidy Monitor is a monthly newsletter intended for users of Sorcerer microcomputers. The newsletter contains programs and other technical articles plus a software library buyer's guide for members and nonmembers. For information, write to *The Exidy Monitor*, c/o Computer Mart of Massachusetts, 1395 Main St, Waltham MA 02154.

Computer Club in Central Nebraska

Compusers is a new club for anyone interested in computing, particularly owners or prospective owners of microcomputers of any make. Meetings are held on the third Monday of each month at 8 PM. Dues, by-laws, and permanent officers are not yet established. For more information, contact Rocky Friend, POB 2064, Hastings NE 68901. Their monthly newsletter is also available from the same address.

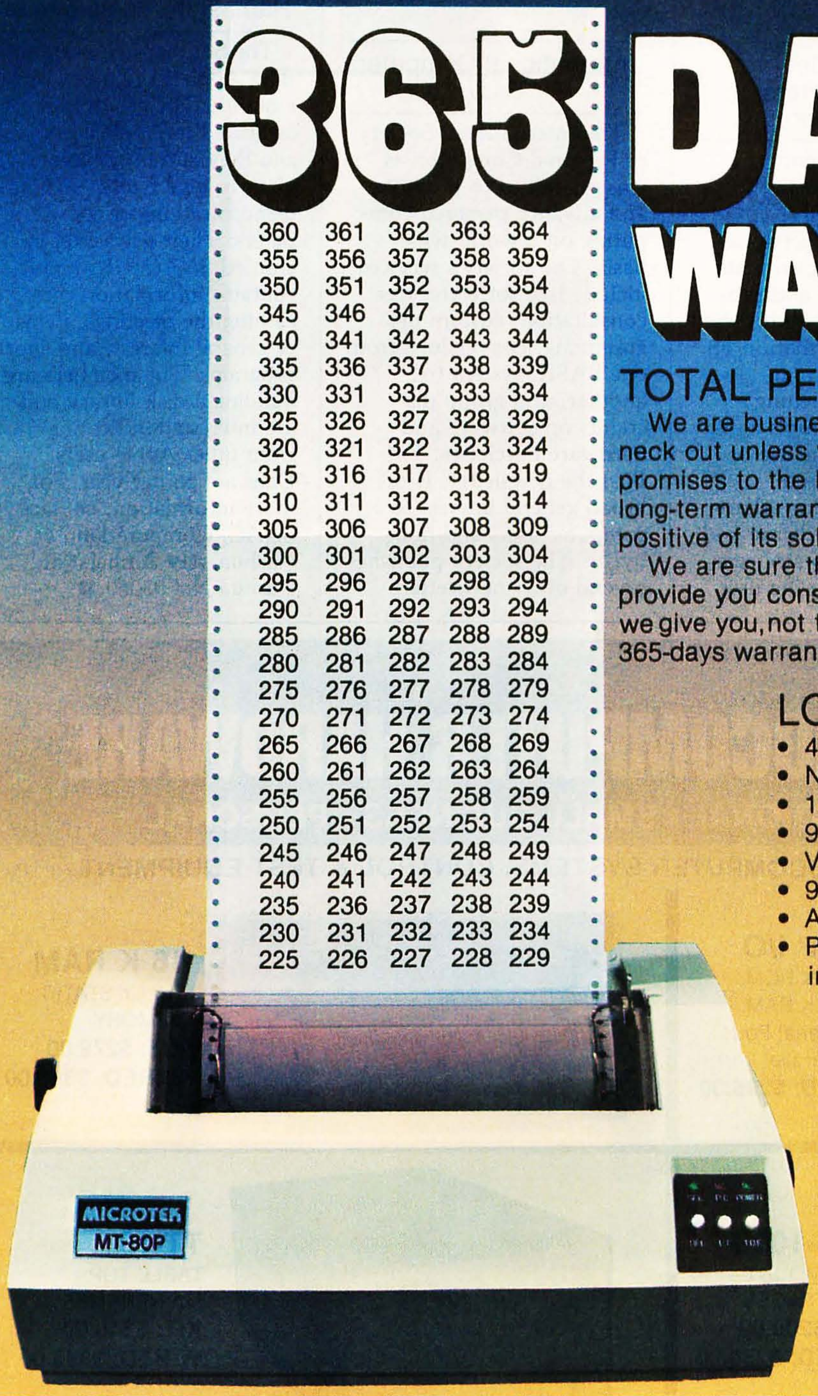
West German Microcomputer Club for Radio Amateurs

The DAFG/GART German Amateur Radio Teleprinter Group has 1300 members who use SDK-85, KIM-1, PET 2001, TRS-80, Apple II, and other microcomputers for amateur radio operation in RTTY, FAX, SSTV, or CW. The membership fee is DM 35.00 annually. The newsletter, *RTTY*, is published six times a year. For more information, contact Manfred N May, Herrenstr.56, D 5014 Kerpen-Sndf. Or contact R F Matthaei, Beisserstr.45, D 2000 Hamburg-63, uC-Referat, WEST GERMANY.

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Ontario Society for Microcomputers in Education

A group of seventy educators have started the Ontario Society of Microcomputers in Education in order to coordinate individual efforts and provide a clearinghouse for the exchange of information on equipment, curricular materials, and teaching methods. The group's aims are to promote the use of microcomputers in all aspects of education, share knowledge of hardware and software, develop strategies for demonstrating the uses of microcomputers in the classroom, to assist in the development of software to meet specific curricular needs, and more. For more information, contact N Solntseff, Unit for Computer Science, McMaster University, Hamilton, Ontario, L8S 4K1 CANADA.

International Computer Club

The International Society of Personal Computerists was organized to promote and advance personal computing on a world-wide basis. The society's services include free software, free consultation, custom programming, conversions from one BASIC system to another, and group discounts on software and hardware purchases. *TidBits*, the newsletter, is of broad general interest to computer users and hobbyists. The society publishes several other newsletters tailored to Apple users, Heath users, TRS-80 users, beginners, and nonusers. Membership is $15. Contact International Society of Personal Computerists, 4554 Cristy Way, Castro Valley CA 94546.

Southern New Hampshire Apple Group

The Southern New Hampshire Apple Core meets once a month. The group is dedicated to Apple users, and they currently have plans to give public demonstrations of computers. Their newsletter is entitled *SNAC Facts* and it contains information concerning the meetings, items of general interest, and short programs. The members are building a disk library and are interested in hearing from other Apple users. Dues are $6 per year. For more information, contact SNAC, Computerland of Nashua, 419 Amherst St, Nashua NH 03060.■

Implementing Dynamic Data Structures with BASIC Files

Ted Carter
902 Pinecrest
Richardson TX 75080

In many computer applications where a large amount of information is to be stored, the need arises to sort, insert, and delete items efficiently using random-access tape or disk-based files. A common method of implementing a mailing list, for example, is to add new names to the end of the current file and to delete names by putting a blank field in place of the names to be deleted. This minimizes the number of time-consuming reads and writes to the file.

However, when this mailing list has to be printed in zip-code order, for example, the task becomes extremely slow as the number of names increases. This is because the number of file accesses increases exponentially with the number of items to be sorted. One possible solution is to actually sort the file so that it is always in order. This is impractical because it necessitates the same sort operation as before, plus a complete rewrite of the file.

With close examination of the problem, you might decide that the file should always be kept in order by inserting a new name in its proper place. This is a good idea, but requires that you must move, on the average, N/2 names (for a file of N names) to make room for the new names. Again, with large files, this may take an inordinately large amount of time.

In order to solve these problems successfully and efficiently, you need a data structure that will permit an insertion and deletion of components without having to worry about where new components fit or what happens to the empty space left by deletion. The tool needed to create such a structure is called a *pointer*. This is simply a number that points to the location of a desired piece of data. Using disk files, for example, a pointer to a piece of data is its actual record number on the disk file. This takes advantage of the random access capabilities of a disk file so as to directly locate and read the data using the pointer value.

Using pointers, a *linked list,* the simplest type of dynamic data structure, can be built. In order to build the linked list, every data record must be accompanied with a pointer to the next element in the linked list. Therefore, space must be reserved in the file for a pointer value within each data record.

A linked list is shown pictorially in figure 1. In a disk file, for example, you could store the base pointer value in the first record of the file. However, you need some way of knowing that the last data item Z does not point to anything. This can be accomplished by storing some special number not in the range of possible pointer values, such as zero, as the pointer value associated with the last data item. An important thing to realize is that records X, Y, and Z can *physically* be in any order on the disk. However, they are *linked* in order and can be retrieved in order with absolutely no comparing or sorting.

Record insertion is also relatively simple. The ordered list is scanned until the element to be added is greater than or equal to the current

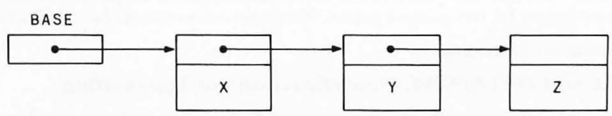


Figure 1: *Example of a linked list. In this picture, X, Y, and Z are records containing the information that is to be stored. The boxes on top represent a portion of memory connected with each record that contains the address of the next record in the list. These are called pointers. The first record in the file, called the base record, points to the first data record in the file but does not contain data itself. This is because the base record also contains a pointer (not shown) to the first available space for new records.*

About the Author

Ted Carter is employed at the Texas Instruments Corporate Engineering Center. In 1978, he founded Software Industries, a custom software house. His interests include computer speech synthesis and computer automation.

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The number of file accesses increases exponentially with the number of items to be sorted.

element and less than the next element in the list. The new element is then inserted between these two elements. For example, assume that Y2 is to be inserted before Z and after Y, as in figure 2a. This is achieved by placing Y2 physically in the first free position on the file, making Y2 point to where Y pointed, and making Y point to Y2, as in figure 2b.

The process of deleting an element is easier. Consider deleting Y2 from the list in figure 2b. By making Y point to where Y2 pointed before Y2 was deleted, the result is the list in figure 2a.

In some situations, an improvement on the linked-list data structure is the *doubly linked ring*, shown in figure 3. With this structure, you may scan from either direction, often facilitating an insertion and deletion either before or after an element. For ease of explanation and understanding, a simple singly linked list as in figure 1 will be used in the examples given in this article.

Implementing the Linked List

When implementing a linked list using random-access files, some additional problems must be solved. An element can be inserted in the linked list easily enough, but the computer must know where the first empty disk file ·is located. Secondly, when deleting an element, the disk file location of the deleted record should be recovered for later use.

These problems could be solved by marking the record to be deleted and later searching for the first empty or marked record when adding a new element. A much better solution is to create a linked list of free records. When adding a new element, a record is taken out of the linked list of free records and inserted in the ordered

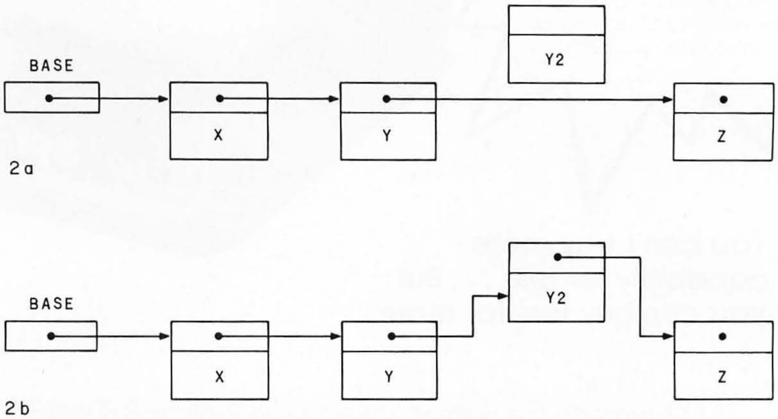


Figure 2: *The process of insertion in a linked list. Figure 2a shows a new record, Y2 (probably physically located after nodes X, Y, and Z), before it is linked into its proper place in the list. To link it into the list, as in figure 2b, only the pointers in Y and Y2 must be changed.*

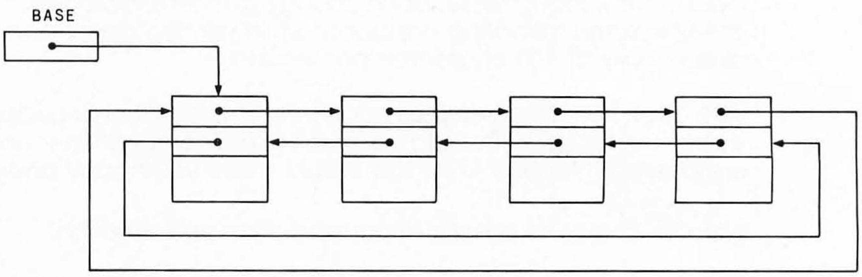
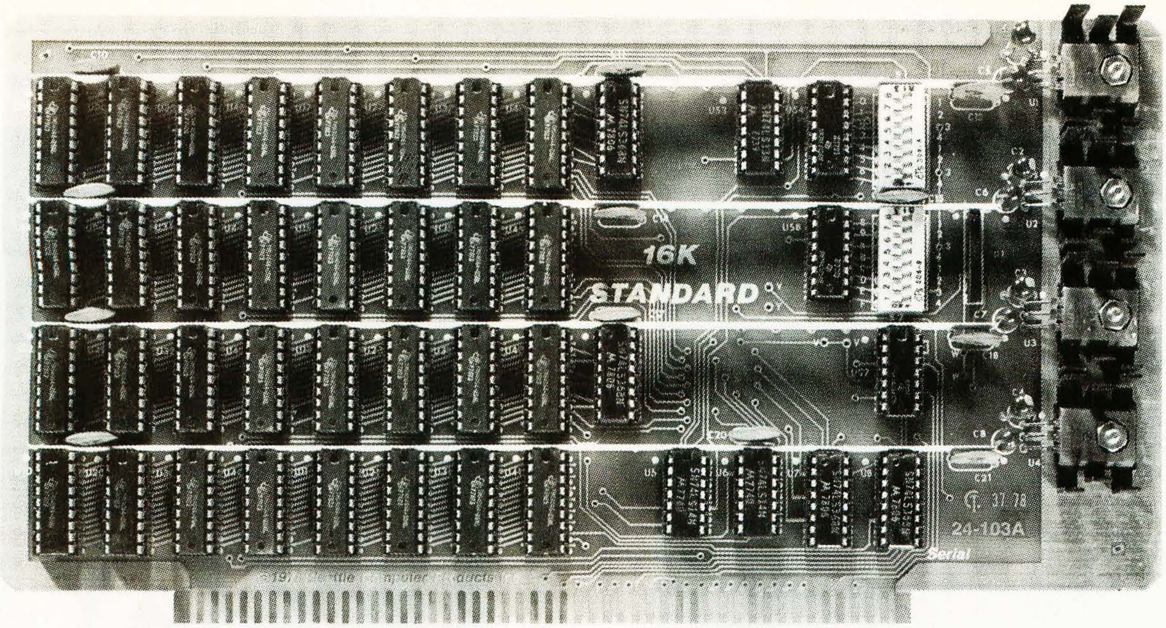


Figure 3: *Example of a doubly linked ring. In this kind of linked list, each record contains a pointer to the previous as well as to the next record in the list. This has certain advantages in some applications, although it creates more memory overhead in each node. Doubly linked lists are not discussed in this article.*



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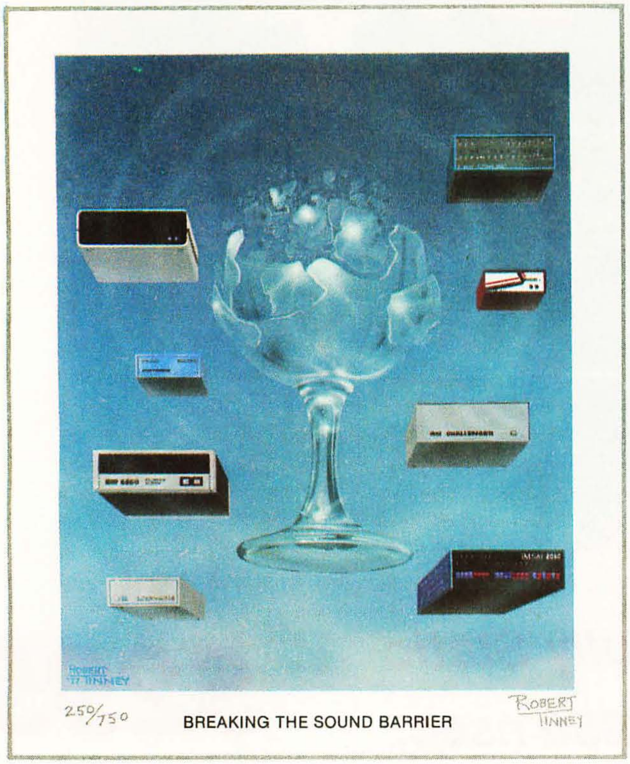
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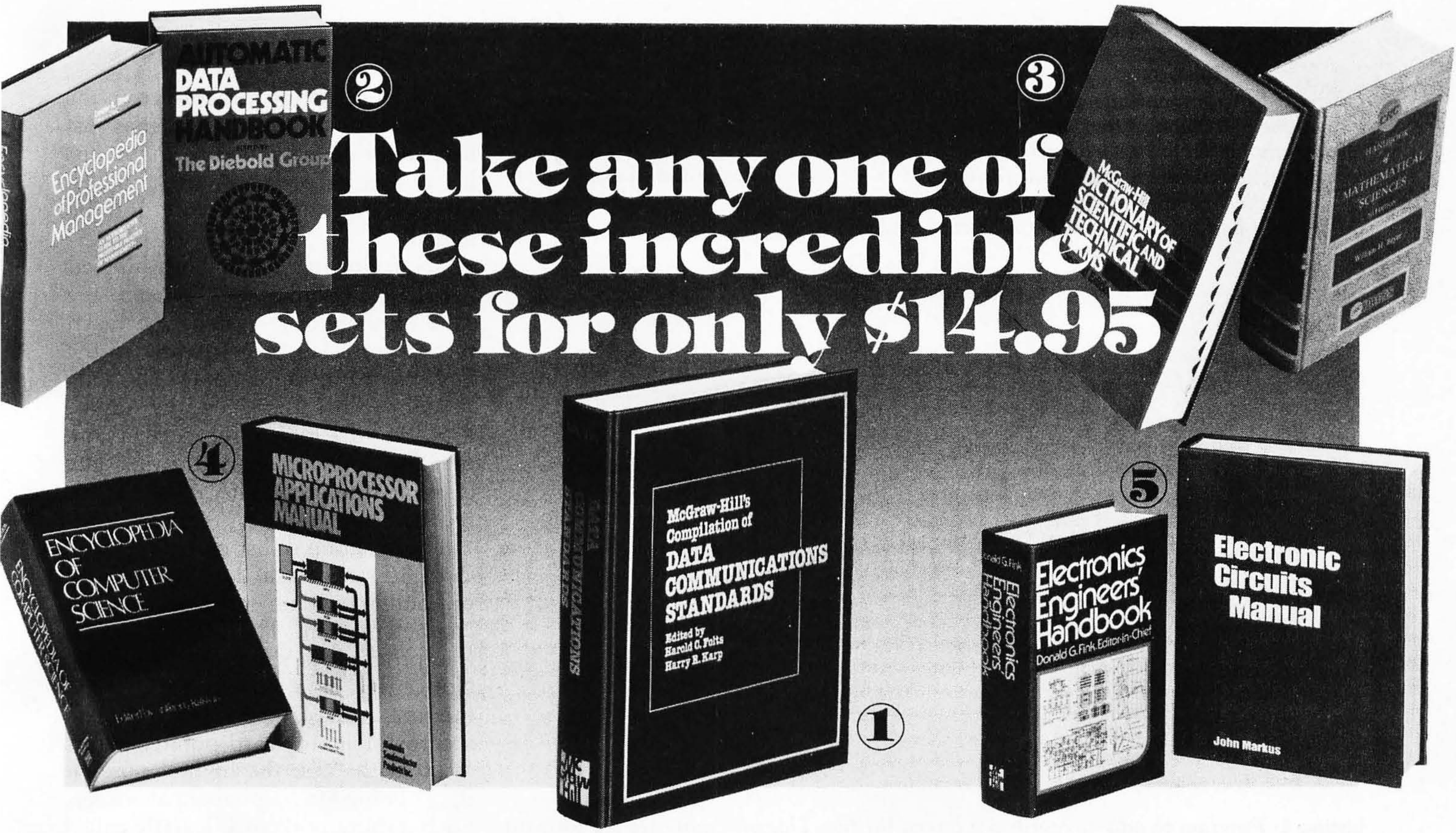
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Listing 1: *Program to create a linked list file. This program, written in CBASIC, creates a small file that contains forward pointers to the next available record. The first record, which is initialized to "2,3", points to the first data record in the file (record 2) and to the first empty (available) record in the file (record 3). The second record, initialized in line 25, is a sentinel record that denotes the end of the file. It is always the last data record in the file and has a forward pointer of zero.*

```
      REM   CREATE A FILE WITH A LINKED LIST OF FREE RECORDS
      REM   ------------------------------------------------------------
      REM
      REM---There will be 10 free records in the sample file.
10          FILELENGTH=10
      REM---Create the file with a record length of 22, give
      REM---it the file number of one.
15          CREATE "DATA.FIL" RECL 22 AS 1
      REM---Put pointer in for the ordered linked data list
      REM---and list of free records.
20          PRINT #1; 2,3
      REM- --Put senterial with highest possible value at end
      REM---of linked list of data.
25          PRINT #1; 0,"zzzzzzzzzzzzzz"
      REM---Create the linked list of free records by making
      REM---each one point to the next record.
30          FOR Z=4 TO FILELENGTH+2 : PRINT #1; Z,"" : NEXT Z
      REM---Make the last free list record pointer equal
      REM---zero to signify the end of the list.
35          PRINT #1; 0,""
40          CLOSE 1
```

Listing 2: *Program to add a record to a linked list file. This program uses the forward pointers to chain through the linked list until the proper place for the new record is found. The only pointers that need to be changed are those on the record being added and the record immediately preceding it.*

```
      REM   THIS PROGRAM ADDS SOME ALPHANUMERIC DATA TO OUR FILE
      REM   WHILE KEEPING IT IN ALPHABETICAL ORDER.
      REM   ------------------------------------------------------------------
      REM
      REM---Open file #1 with record length of 22.
10          OPEN "DATA.FIL" RECL 22 AS 1
      REM---Set pointers to start of linked lists.
15          READ #1,1; BASEPOINTER, NEXTFREE
20          IF NEXTFREE=0 THEN PRINT"File is full" : GOTO 90
      REM---Get data to add.
25          INPUT"New data:";NEWDATA$
      REM---Left justify data in a field of blanks.
30          NEWDATA$=LEFT$(NEWDATA$+"              ",14)
      REM---Set pointers to start of list.
35          POINTER=BASEPOINTER : NEXTPOINTER=BASEPOINTER
      REM---Search loop which traverses the linked list to
      REM---find the proper place to insert the new data.
40          TRAILPOINTER=POINTER : PREVDATA$=DATA$
45          POINTER=NEXTPOINTER : READ #1,POINTER; NEXTPOINTER,DATA$
50          IF NEWDATA$>DATA$ THEN 40
      REM---Insert our NEWDATA$ in the linked list
      REM---after the element pointed to by TRAILPOINTER.
         REM---Get the place to physically put the new record by
         REM---taking a record out of the free linked list.
55             READ #1,NEXTFREE; NEXTRECORD
         REM---If TRAILPOINTER=POINTER, then the base pointer must
         REM---be modified in order to add at the beginning.
60             IF TRAILPOINTER<>POINTER THEN 75
65             PRINT #1,1; NEXTFREE, NEXTRECORD
70             PRINT #1,NEXTFREE; BASEPOINTER, NEWDATA$: GOTO 90
         REM---Now take record out of free linked list.
75             PRINT #1,1; BASEPOINTER, NEXTRECORD
         REM---Now make the new item point to where the record
         REM---pointed to by TRAILPOINTER pointer, make the record
         REM---pointed to by TRAILPOINTER point to new item.
80             PRINT #1,NEXTFREE; POINTER, NEWDATA$
85             PRINT #1,TRAILPOINTER; NEXTFREE, PREVDATA$
90             CLOSE 1
```

list. When deleting a record from the ordered list, the record that has just been removed is added to the linked list of free records so that it can be used the next time an element is to be added.

The following example uses linked lists and random-access files. For the sake of simplicity, assume that each record consists of one pointer to the next record in the list and one string of data. Since there are two linked lists, the first logical record will contain two pointers, one to the first data element, the second to the first free record.

The program of listing 1, written in CBASIC, creates a data file capable of holding ten data entries of fourteen characters each. The file created by this program is shown in listing 5a. Notice that data record number two, the first in the linked list of data, has a zero for its forward pointer and is filled with "z"s, the highest possible data going in alphabetical order. Such a dummy record, usually called a *sentinel*, will always be the last element of the linked list. The sentinel is also used to locate the end of the linked list when the linked list is traversed in ascending order. Although programs can be written without the sentinel record, the sentinel greatly simplifies them.

The program of listing 2 adds a record to the linked list. It gets the data to be added and scans the linked list (keeping a pointer to the previous record) until the record to be added is alphabetically less than the one being read. When this occurs, the new item should be added immediately before the one being read. This is accomplished by making the new record point to the record being read and making the previous record point to the new record. When inserting a new item at the very beginning of the linked list, a special case exists that must be accounted for, since the base pointer in the first record must be changed to point to the new record.

Listing 5b shows what the data looks like after adding a piece of data named "First item". Listing 5c and listing 5d show the contents of the file after the addition of several new entries to the file. Note that the path of the linked list is such that the data is always in alphabetical order.

Listing 3: *Program to list a linked-list file. This program uses the forward pointers to print out the records in the order in which they are encountered. This example corresponds to printing out the data fields in ascending alphabetic order.*

```
     REM   THIS PROGRAM LISTS OUR ALREADY SORTED FILE.
     REM   ------------------------------------------------
     REM
     REM--Open file #1 with record length of 22.
10         OPEN "DATA.FIL" RECL 22 AS 1
     REM--Set pointer to start of linked list.
15         READ #1,1: POINTER
     REM--Loop to traverse list and print data
     REM--until POINTER is zero.
20         READ #1,POINTER; POINTER,DATA$
25         IF POINTER<>0 THEN PRINT DATA$ : GOTO 20
30         CLOSE 1
```

Listing 4: *Program to delete a record from a linked list file. This program deletes a given record by changing the pointer of its previous record. The pointers in record 1 and the deleted record are changed so that this record is the first record of the linked group of free (available) records.*

```
     REM   DELETE A DATA ITEM FROM OUR MAIN LINKED LIST AND
     REM   ADD IT TO OUR LINKED LIST OF FREE RECORDS.
     REM   ----------------------------------------------------
     REM
     REM--Open file #1 with record length of 22.
10         OPEN "DATA.FIL" RECL 22 AS 1
15         INPUT"Data to delete:";DATA$
     REM--Left justify data in a field of blanks.
20         DATA$=LEFT$(DATA$+"                    ",14)
     REM--Set pointers to beginning of linked list.
25         READ #1,1: BASEPOINTER, NEXTFREE
30         POINTER=BASEPOINTER: NEXTPOINTER=BASEPOINTER
     REM--Search loop traverses the linked list until it
     REM--finds a match or runs out of data.
35         TRAILPOINTER=POINTER: PREVDATA$=DATAIN$
40         POINTER=NEXTPOINTER
45         READ #1,POINTER: NEXTPOINTER, DATAIN$
50         IF NEXTPOINTER=0 THEN PRINT"No match found.": GOTO 75
55         IF DATAIN$<>DATA$ THEN 35
     REM--Delete the record pointed to by POINTER by making the
     REM--record pointed to by TRAILPOINTER point to the record
     REM--after the one pointed to by POINTER.
60         IF TRAILPOINTER=POINTER THEN BASEPOINTER=NEXTPOINTER \
              ELSE PRINT #1,TRAILPOINTER: NEXTPOINTER, PREVDATA$
     REM--Add the now unused record pointed to by pointer to the
     REM--free linked list.
65         PRINT #1,POINTER: NEXTFREE,""
70         PRINT #1,1: BASEPOINTER, POINTER
75         CLOSE 1
```

The program of listing 3 and its output in listing 5e will clarify any confusion in following the list. This program traverses the linked list of data and prints each item out as it is read. It can be concluded, from the brevity of listing 3, that printing a sorted list is much easier with the use of a linked-list file organization.

Listing 4 shows the solution to the problem of deleting a given data item and placing the free space back into the linked list of free records. The program scans the linked list until it reaches the end of the file or finds the data to be deleted. When the data to be deleted has been found, the previous record is made to point to where the deleted record points. As in listing 2, deleting the first item in the linked list results in a special case, and the base pointer must be modified. The deleted record is then added to the linked list of free records. Listing 5f shows the data file after the "Fourth" data item has been deleted. Note the "6" in the first line of listing 5f, which points to the first free record, the record that has just been deleted.

Although the concept of the linked list may be difficult to understand, it is a very powerful tool. If, in the mailing list example, the information needs to be sorted by more than one field, it is simple to create a linked list for each field to be sorted and to make room for the additional pointers.

Other modifications are possible; for example, the linked list could spread over more than one file on a disk or over more than one disk by having the pointers preceded by a

Listing 5: *Examples of linked list files. The contents of the file created by listing 1 are shown in listings 5a, 5b, 5c, 5d, and 5f. In each case, the records are numbered 1 through 12, with record 1 at the top. Listing 5a shows the contents of the file just after it has been created by the program in listing 1. Listings 5b, 5c, and 5d show the file after one, two, and five records, respectively, have been added. Listing 5e shows the result of running the program of listing 3. The data appears listed in ascending alphabetic sequence. Listing 5f shows the file after the fourth node has been deleted. Note that the available record pointer in record 1 points to line 6, the location of the line that has just been deleted.*

The concepts of linked lists and pointers can also be used to handle data that has a variable amount of additional information associated with it.

(5a)

```
2,3
0,"zzzzzzzzzzzzzz"
4,""
5,""
6,""
7,""
8,""
9,""
10,""
11,""
12,""
0,""
```

(5b)

```
3,4
0,"zzzzzzzzzzzzzz"
2,"First item    "
5,""
6,""
7,""
8,""
9,""
10,""
11,""
12,""
0,""
```

(5c)

```
3,5
0,"zzzzzzzzzzzzzz"
4,"First item    "
2,"Second item   "
6,""
7,""
8,""
9,""
10,""
11,""
12,""
0,""
```

(5d)

```
7,8
0,"zzzzzzzzzzzzzz"
6,"First item    "
5,"Second item   "
2,"Third         "
4,"Fourth        "
3,"Fifth         "
9,""
10,""
11,""
12,""
0,""
```

(5e)

```
A>R2 LIST

CRUN VER 2.04

Fifth
First item
Fourth
Second item
Third
```

(5f)

```
7,6
0,"zzzzzzzzzzzzzz"
4,"First item    "
5,"Second item   "
2,"Third         "
8,""
3,"Fifth         "
9,""
10,""
11,""
12,""
0,""
```

digit specifying the file or disk-drive number. A slightly better solution for very large data bases is to use pointers to create a tree structure. However, operations involving trees are very involved, and a discussion of them is outside the scope of this article. Those interested in this subject are encouraged to read the book *Algorithms + Data Structures = Programs* by Niklaus Wirth, listed in the references.

Uses of the Linked List

The concepts of linked lists and pointers can also be used to handle data that has a variable amount of additional information associated with it. One particular problem that is unmanageable without linked lists involves a theatre-booking program where you have a movie film and an unknown, highly variable number of dates for which it is scheduled to be used. Because of the uncertainty involved with the scheduling process, it is usually unacceptable to either limit the number of dates that can be associated with a film or to reserve enough space per film to handle even the most heavily scheduled film.

One solution to this scheduling problem makes use of a linked list. A file containing the essential information for each film can also have, for each record describing a film, a pointer that points to a linked list of date records (each record containing a date and its associated information). Traversing the linked list of dates for any one film is both fast and easy, and each film takes up only as much space for date records as is needed.

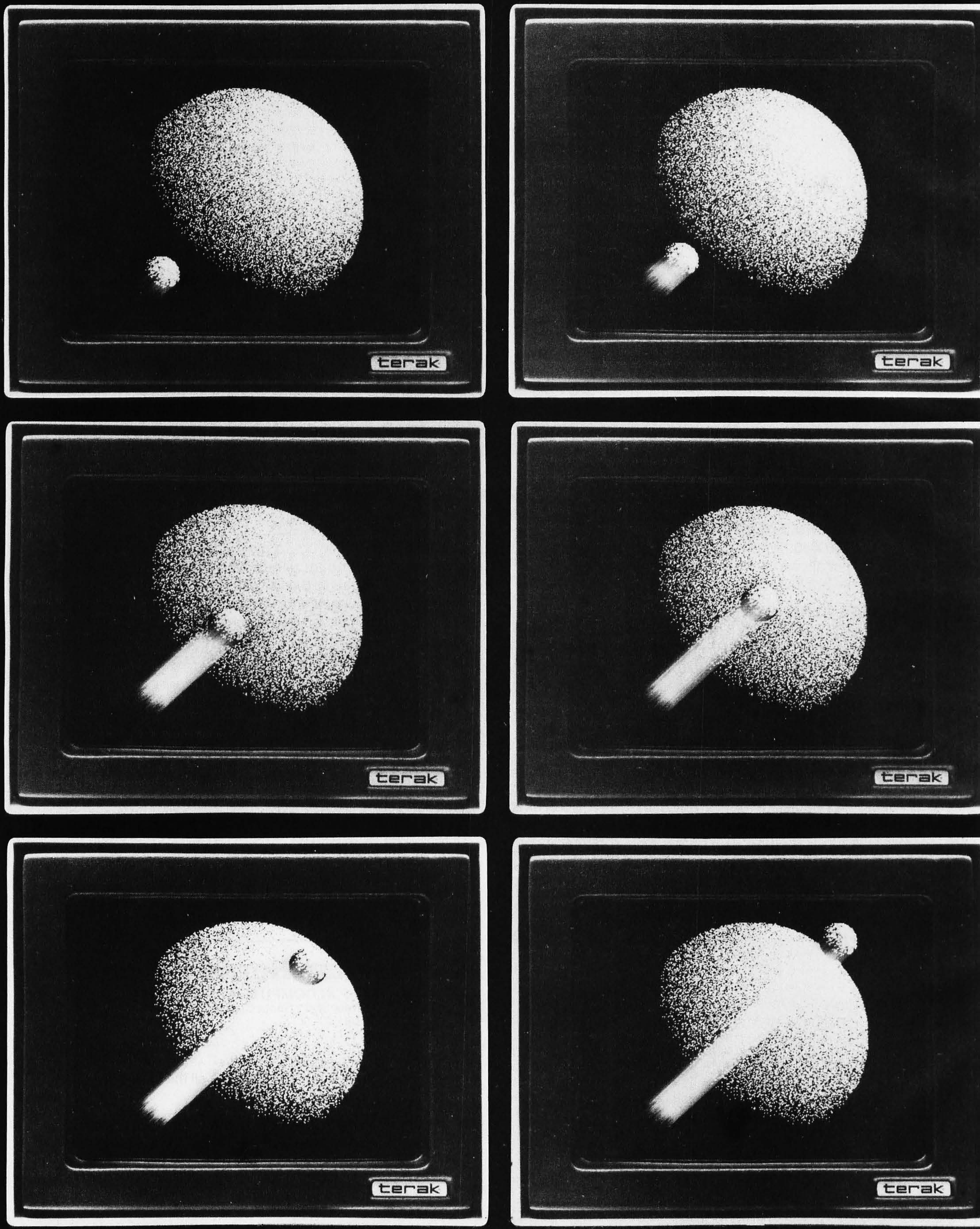
The programs and ideas presented here can be converted to work in any programming language that allows some sort of random-access files. In cases where a linked list is applicable, necessity for the additional storage space for the pointers and the slightly increased program complexity are both far outweighed by the ability to directly access related data items with a minimum of searching and sorting.

The difficulty arises in determining whether or not to use linked lists in a particular application. There are, unfortunately, no fixed criteria since the choice of a method will depend on such factors as the computer's disk capabilities, the number of data items, the length of the data items, how often the data will be sorted, and how often the data base will change. You should, however, plan the data base before doing any programming, taking into account the possible methods and the tradeoffs involved. ■

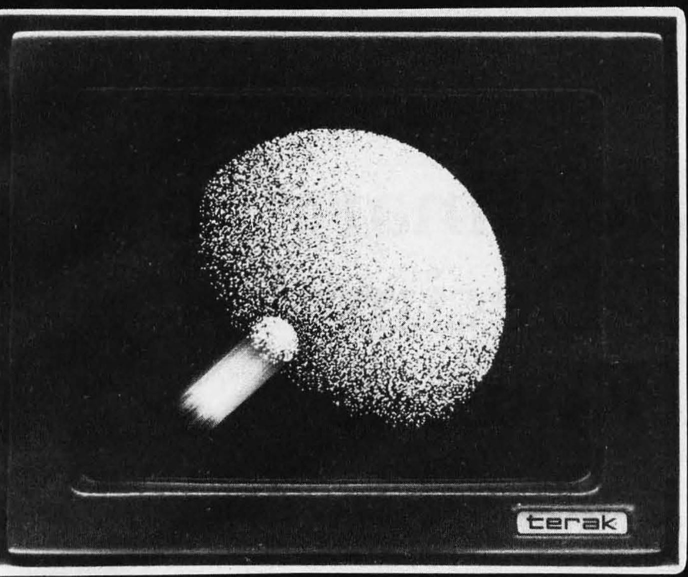
REFERENCES

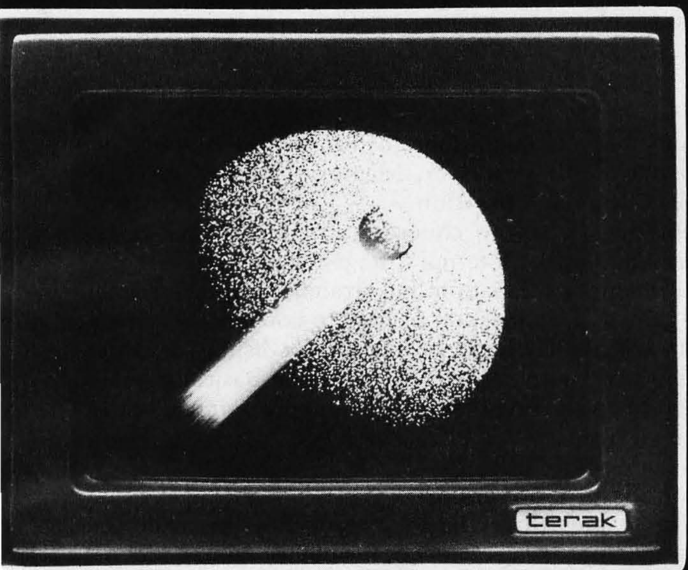
1. Grogono, Peter, *Programming in Pascal*, Addison-Wesley, Reading MA, 1973.
2. Wirth, Niklaus, *Algorithms + Data Structures = Programs*, Prentice-Hall, Englewood Cliffs NJ, 1976.

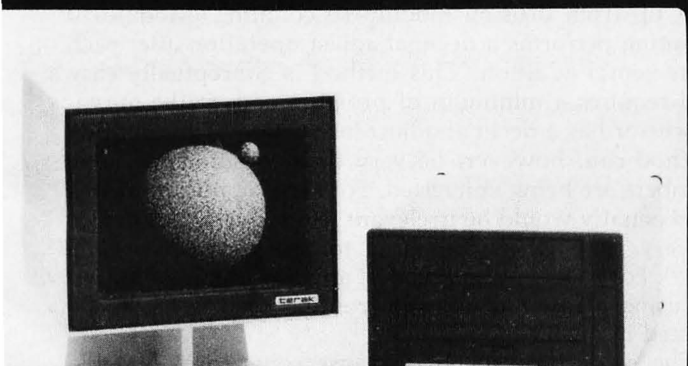
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A Fast, Multibyte Binary to Binary-Coded-Decimal Conversion Routine

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Atlanta GA 30332

A problem which has confronted users of small computer systems over the years has been the incompatibility of the number representation required by output devices and that used for internal processing. Output devices used by the small systems need to receive binary-coded-decimal (BCD) or ASCII (American Standard Code for Information Interchange) data representations, while the microprocessor is most efficient when handling a straight binary number. Several solutions to the problem exist, and as would be expected, each has its own advantages and disadvantages.

Some users choose to initially store all numbers in their binary-coded-decimal representation and do all subsequent processing in this format. This has the advantage of easy and quick conversion of the numbers into the required output format. At worst, the binary-coded-decimal represented number must be converted to an ASCII format. This requires attaching a fixed 4-bit prefix to each binary-coded-decimal digit.

A disadvantage associated with this approach is that arithmetic operations take longer to perform, since the results must be decimally adjusted after each operation. Also, more memory is required to store the binary-coded-decimal form of the number than is required for its straight binary equivalent. A direct result of this increased memory requirement is the need to perform more memory-access operations to transfer the numbers into and out of the processor. Memory accesses are a very time-consuming operation.

For the users who choose a straight, binary-number representation for internal storage, the advantages of efficient memory utilization and straightforward arithmetic are gained. The question of how to convert the numbers to an acceptable output format for the display device still remains to be answered. This question basically reduces down to converting the binary numbers to binary-coded-decimal form.

Methods of Conversion

There are three basic approaches in wide use. The first approach is to count the binary number down to 0 while incrementing its binary-coded-decimal counterpart up from 0 using modulo-10 counting. Modulo-10 counting performs a decimal-adjust operation after each incremental addition. This method is conceptually easy and requires a minimum of program code if the microprocessor has a decimal-adjust instruction. The counting method can, however, be very time-consuming if large numbers are being converted. For some applications this time penalty would be irrelevant (eg: if the output device is very slow when compared to the processor's cycle time). For a slow output device, any time savings realized by using a faster conversion routine usually has to be wasted in a wait loop.

The second approach is to use some form of table lookup routine. Assuming that the table is extensive enough, the lookup technique performs a very fast conversion. The drawback to this technique is that as the size of the numbers being handled gets larger, either a great deal of memory must be dedicated to the table, or some type of divide-with-remainder scheme must be imple-

About the Author

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mented. The division scheme allows the table size to remain small, but it causes the conversion time to increase. As was pointed out earlier, this may not be important. If the processor being used does not have a decimal-adjust instruction and the numbers encountered are not too large, this second method is very popular.

The third approach in converting from straight binary to binary-coded decimal is to use an algorithm based on the structure of the binary number system. Given the binary number:

$$b_n\ b_{n-1}\ b_{n-2}\ .\ .\ .\ b_2\ b_1\ b_0$$

where each of the bs can represent either a 1 or a 0, and b_n is the most significant bit, it can be expanded as:

$$b_n \times 2^n + b_{n-1} \times 2^{n-1} + \ldots + b_1 \times 2^1 + b_0 \times 2^0 \quad \text{(Form I)}.$$

Form I is not conducive to an iterative-type binary to binary-coded decimal conversion routine, but can be rewritten as:

$$(\ldots((b_n \times 2) + b_{n-1}) \times 2 + \ldots + b_1) \times 2 + b_0 \quad \text{(Form II)}.$$

Form II contains only the decimal numbers 0, 1, and 2, which have the same representations in either straight binary or binary-coded decimal. Straight binary and binary-coded-decimal representations of a number differ only for numbers greater than 9. While straight binary adheres strictly to position weighting in powers of 2, binary-coded decimal treats each decimal digit of the number *independently* and represents it as a 4-bit straight binary number.

If Form II is implemented using binary-coded-decimal arithmetic (performing a decimal adjust after each addition), the final result will be in binary-coded-decimal representation. Form II lends itself to an iterative-type implementation which allows it to be coded to easily accommodate any size number.

Carry	Auxiliary Carry	Correction Factor
0	0	10011010
0	1	10100000
1	0	11111010
1	1	00000000

Table 1: *Correction factors in binary for the binary to binary-coded-decimal (BCD) conversion algorithm.*

Much has been said about performing a decimal-adjust operation when operating on numbers in the binary-coded-decimal format. When two binary-coded-decimal numbers are added by the processor's straight binary-adding accumulator, the result is not in binary-coded-decimal form. It is necessary to perform one more operation after each addition to correct for the fact that the processor's arithmetic logic is designed to add *straight* binary numbers. This extra operation is the decimal adjust. Many of the microprocessors on the market today have the decimal-adjust operation contained in their instruction sets.

If the processor being used does not contain a decimal-adjust instruction, it is still possible to perform a decimal-adjust operation. What must be done is to allow for the fact that a binary-coded-decimal number uses only ten of the sixteen possible 4-bit combinations for each digit. If two binary-coded-decimal numbers are added together, and the least significant 4 bits of the result have a value greater than 9, then 6 must be added to the result. It is necessary to add 6 to skip over the six unallowed BCD bit combinations. The next 4 bits of the result are then tested, and 6 is added to them if necessary. This is repeated across the entire result.

A Better Method

The above method works in theory but is rather awkward to program. Let us examine a method based on the above theory which lends itself to straightforward programming. The method will be for 8-bit processors,

Listing 1: *The multibyte binary to binary-coded-decimal (BCD) conversion algorithm coded as a subroutine for the 8080 microprocessor.*

```
                ;THE SUBROUTINES ALWAYS SAVE THE CONTENTS OF REGISTERS A
                ;D E H L AND THE STATUS FLAGS.  IF THE CONTENTS OF REGISTERS
                ;B C NEED TO BE SAVED THE CALLING ROUTINE MUST EXPLICITLY DO IT.

                ;******************BINARY TO BCD CONVERSION SUBROUTINE******************

                ;THE SUBROUTINE CONVERTS A MULTI-BYTE BINARY NUMBER TO ITS EQUIVALENT
                ;MULTI-BYTE BINARY CODED DECIMAL (BCD) REPRESENTATION.  THE BYTES
                ;OF BOTH NUMBERS ARE STORED IN MEMORY IN ASCENDING ORDER WITH
                ;THE LEAST SIGNIFICANT BYTE IN THE LOW END OF THE MEMORY STACK.  THE
                ;REQUIRED PARAMETERS NEEDED TO BE PASSED ARE:

                ;               H L GETS ADDRESS OF LOW ORDER BYTE OF BINARY NUMBER
                ;               D GETS NUMBER OF BYTES IN BINARY NUMBER
                ;               E GETS NUMBER OF BYTES IN BCD RESULT AREA

                ;THE SUBROUTINE ASSUMES THAT THE BINARY NUMBER WILL FIT IN THE SUPPLIED
                ;NUMBER OF BCD BYTES.  THE ROUTINE WILL FILL IN THE BCD BYTES WITH
                ;LEADING ZEROS IF NECESSARY.


0000 F5         BNBCD:  PUSH    PSW             ;SAVE STATUS
0001 4B                 MOV     C,E             ;COPY # BCD BYTES TO C
0002 E5                 PUSH    H               ;SAVE ADDR OF BINARY # ON STACK
0003 216400             LXI     H,BCDNL         ;LOAD HL WITH ADDR OF BCD #
0006 3600       LAB16:  MVI     M,0             ;ZERO OUT MEMORY LOCATION
0008 23                 INX     H               ;INCREMENT HL
0009 0D                 DCR     C               ;DECREMENT C
000A C20600             JNZ     LAB16           ;IF C=0 BRANCH FROM LOOP
000D 7A                 MOV     A,D             ;PUT # OF BINARY BYTES IN A
000E 87                 ADD     A
000F 87                 ADD     A               ;MULTIPLY BY 8 TO GET # OF BITS
0010 87                 ADD     A
0011 47                 MOV     B,A             ;STORE # OF BITS IN B
0012 AF                 XRA     A               ;SET CARRY TO ZERO
0013 4A         MLOOP:  MOV     C,D             ;PUT # OF BINARY BYTES IN C
0014 E1                 POP     H               ;RESTORE ADDR OF BINARY # TO HL
0015 3B                 DCX     SP
0016 3B                 DCX     SP              ;LEAVE HL ON STACK
0017 7E         RLOOP:  MOV     A,M             ;PUT BINARY BYTE IN A
0018 8F                 ADC     A               ;SHIFT BYTE LEFT & FILL WITH CARRY
0019 77                 MOV     M,A             ;REPLACE BYTE
001A 0D                 DCR     C               ;DECREMENT C
001B CA2200             JZ      LAB17           ;BRANCH FROM LOOP IF LAST BYTE
001E 23                 INX     H               ;INCREMENT HL
001F C31700             JMP     RLOOP           ;JUMP TO START OF ROTATE LOOP
0022 E1         LAB17:  POP     H               ;RESTORE HL POINTER TO LOW ORDER BINARY BYTE
0023 3B                 DCX     SP
0024 3B                 DCX     SP              ;LEAVE HL ON STACK
0025 D22900             JNC     LAB18           ;SKIP FILL WITH ONE IF NO CARRY
0028 34                 INR     M               ;FILL WITH ONE
0029 4B         LAB18:  MOV     C,E             ;PUT # OF BCD BYTE IN C
002A 216400             LXI     H,BCDNL         ;LOAD HL WITH ADDR OF BCD
002D 3E00       LAB20:  MVI     A,0             ;ZERO OUT A
002F 8E                 ADC     M               ;ADD BCD BYTE TO A WITH CARRY
0030 27                 DAA                     ;CONVERT RESULT TO BCD
0031 77                 MOV     M,A             ;SAVE NEW BCD BYTE
0032 D23A00             JNC     LAB19           ;SKIP REST IF NO CARRY
0035 23                 INX     H               ;POINT TO NEXT BCD BYTE
0036 0D                 DCR     C               ;DECREMENT C
0037 C22D00             JNZ     LAB20           ;IF C=0 LEAVE LOOP
003A 4B         LAB19:  MOV     C,E             ;PUT # OF BCD BYTE IN C
003B 05                 DCR     B               ;DECREMENT BIT COUNT
003C CA4E00             JZ      LAB40           ;EXIT MAIN LOOP IF COUNT = 0
003F 216400             LXI     H,BCDNL         ;LOAD HL WITH ADDR OF BCD
                                                ;CARRY=0 ENTERING NEXT LOOP WHICH
                                                ;MULTIPLIES BCD # BY TWO
0042 7E         LAB21:  MOV     A,M             ;PUT BCD BYTE IN A
0043 8E                 ADC     M               ;ADD BCD BYTE TO ITSELF WITH CARRY
0044 27                 DAA                     ;CONVERT RESULT TO BCD
0045 77                 MOV     M,A             ;SAVE NEW BCD BYTE
0046 23                 INX     H               ;POINT TO NEXT BCD BYTE
0047 0D                 DCR     C               ;DECREMENT C
0048 C24200             JNZ     LAB21           ;IF C=0 LEAVE LOOP
004B C31300             JMP     MLOOP           ;DO FOR ALL BITS OF BINARY #
004E E1         LAB40:  POP     H               ;RESTORE HL
004F F1                 POP     PSW             ;RESTORE STATUS
0050 C9                 RET                     ;RETURN
```

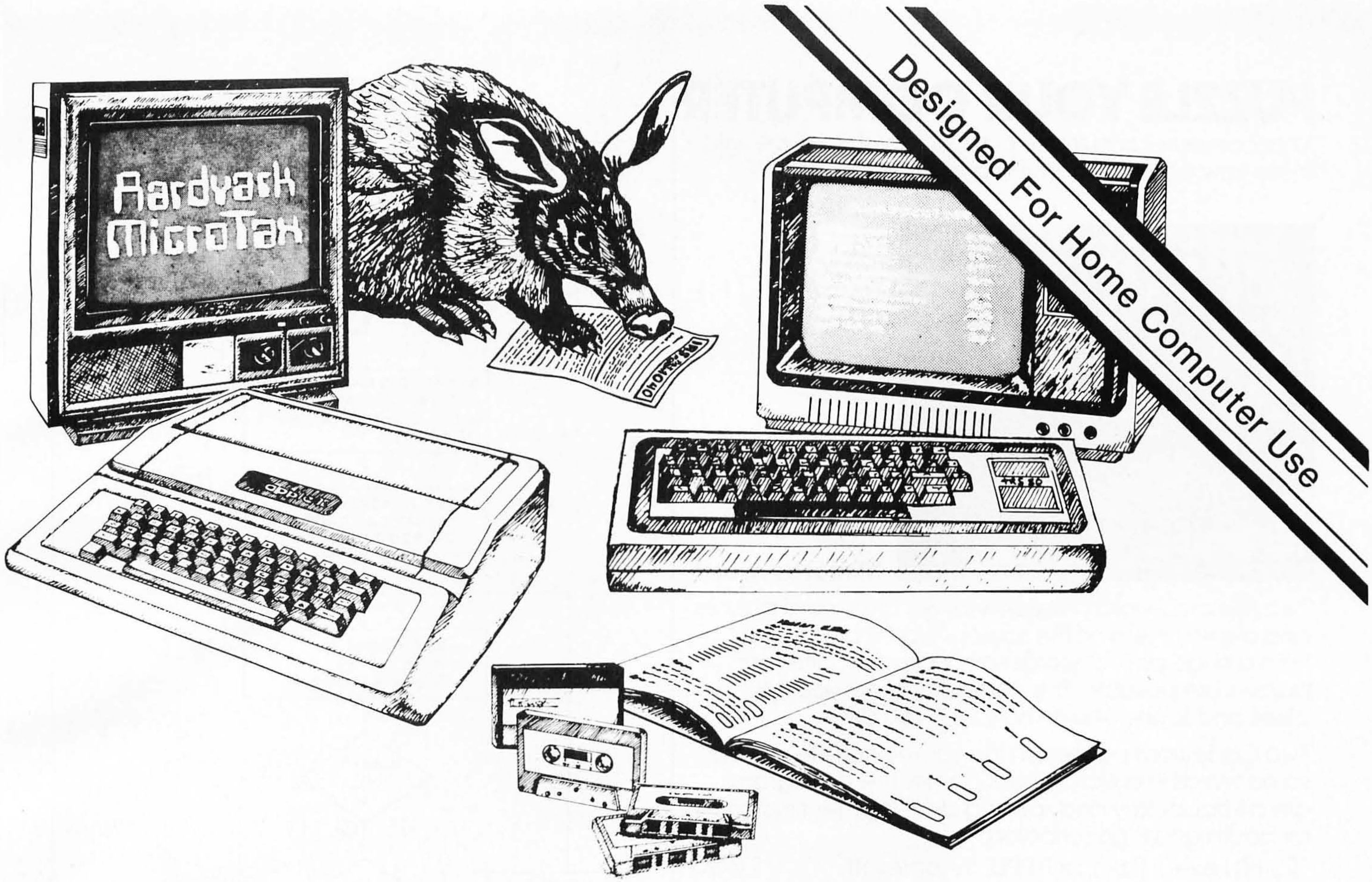
since they are the most popular. First it is necessary to keep track not only of the carry out of the eighth bit position, but also the carry from the fourth to fifth bit position. This second carry will be referred to as the *auxiliary carry*.

(1) Add the binary number 01100110 to the first number.
(2) Add the second number to the result generated in step 1. Keep track of both the carry and auxiliary carry from this addition. The carry generated here is the true carry to the next higher digit.
(3) Based on the carry and auxiliary carry generated in step 2, add one of the correction factors shown in table 1 to the result of step 2.

The result has now been decimally adjusted.

The program shown in listing 1 and the flowchart shown in figure 1 provide an implementation of Form II using binary-coded-decimal arithmetic for the Intel 8080 microprocessor. It uses the decimal-adjust (DAA) instruction in the 8080's instruction set. A simple program shown in listing 2 converts data from binary-coded decimal to ASCII representation. The conversion from binary-coded-decimal to ASCII entails taking each of the two 4-bit, binary-coded-decimal digits, putting them in a byte, and appending the binary prefix 0011. Both programs are coded as subroutines, since these forms are usually more convenient to include in larger programs.

The binary-to-binary-coded-decimal subroutine of



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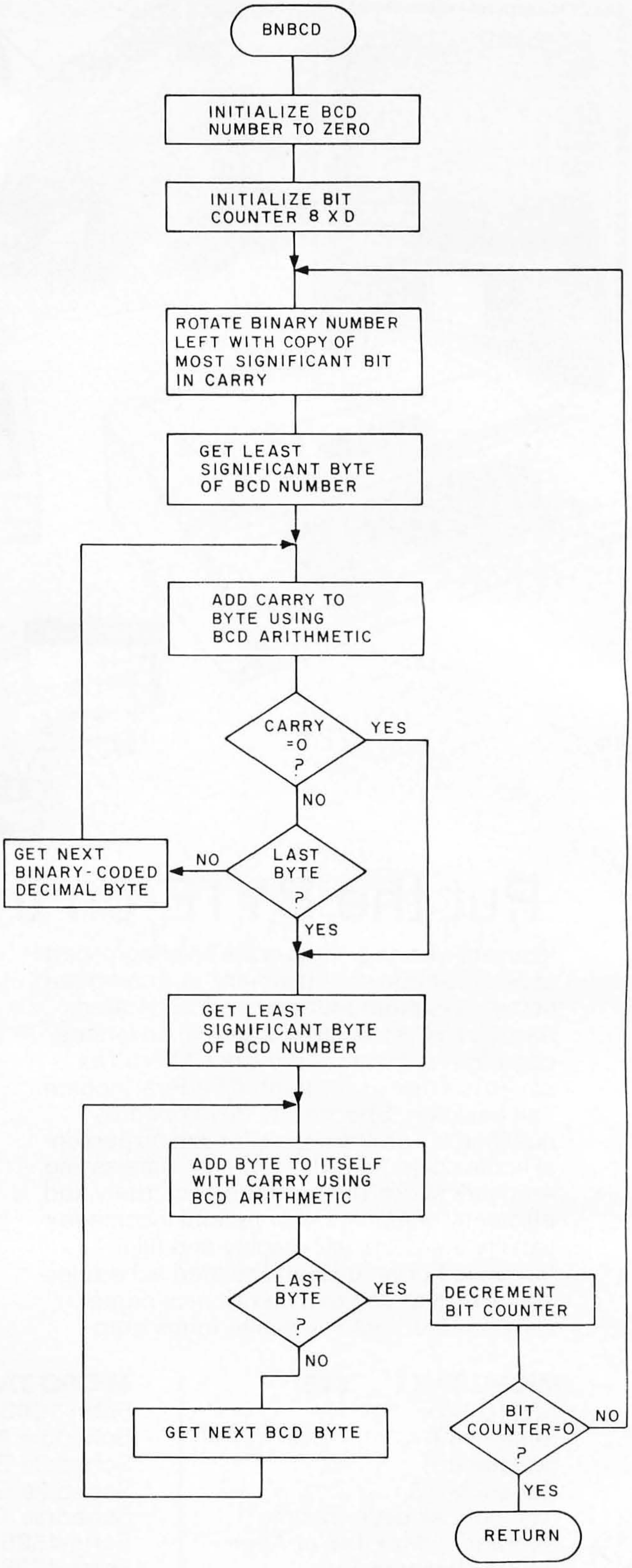


Figure 1: *Flowchart of the algorithm for the binary to binary-coded-decimal (BCD) conversion subroutine.*

listing 1 requires contiguous memory locations to hold the binary-coded-decimal result. The address of the memory location for the low-order byte of the binary-coded-decimal number has been labeled BCDNL (binary-coded-decimal number location) in the subroutine. The

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Listing 2: *A subroutine to convert a single-byte, 2-digit, binary-coded-decimal number to two single-byte ASCII characters, coded for the 8080 microprocessor.*

```
         ;**************BCD TO ASCII SUBROUTINE*************************

         ;THE SUBROUTINE TAKES A TWO DIGIT BCD NUMBER IN MEMORY POINTED TO BY
         ;HL AND CONVERTS IT TO ASCII.  THE MOST SIGNIFICANT DIGIT IS PUT
         ;IN REGISTER B WHILE THE LEAST SIGNIFICANT DIGIT IS PUT IN REGISTER C.

0051 F5    ASCII:  PUSH  PSW          ;SAVE STATUS
0052 3E0F          MVI   A,00001111B  ;PUT LEAST SIGNIFICANT DIGIT MASK IN A
0054 A6            ANA   M            ;MASK OFF LEAST SIGNIFICANT DIGIT
0055 F630          ORI   00110000B    ;CONVERT TO ASCII
0057 4F            MOV   C,A          ;PUT IN REG C
0058 3EF0          MVI   A,11110000B  ;PUT MOST SIGNIFICANT DIGIT MASK IN A
005A A6            ANA   M            ;MASK OFF MOST SIGNIFICANT DIGIT
005B 0F            RRC
005C 0F            RRC
005D 0F            RRC
005E 0F            RRC                ;ROTATE RIGHT FOUR PLACES
005F F630          ORI   00110000B    ;CONVERT TO ASCII
0061 47            MOV   B,A          ;PUT IN REG B
0062 F1            POP   PSW          ;RESTORE STATUS
0063 C9            RET                ;RETURN
0064       BCDNL:  DS    31           ;START OF BCD NUMBER
0000               END
```

number is ordered upwards in memory. Register E must contain the number of bytes in the binary-coded-decimal number when the subroutine is called. If more bytes are specified than are needed, the extra will be filled with leading zeros.

The other parameters which must be passed to the subroutine are the number of bytes in the binary number and the address of the low-order byte of the binary number. The number of bytes in the binary number is to be in register D, while the address of the low-order byte is in register pair HL. The binary number is assumed to be stored in memory using the same convention as the binary-coded-decimal number. The more significant bytes are found at increasing memory addresses.

By having register pair HL point to the binary number, the routine can be used to convert all binary numbers required by the user's program without moving them to a specific location. All results are put in the same location, since this is temporary storage needed only until the number is sent to the display device.

The binary to binary-coded-decimal conversion subroutine provided can handle binary numbers of any length up to and including 31 bytes. This corresponds to a decimal number in excess of 4.5×10^{74} with a full 75 significant digits. This should be adequate to handle any physical quantity encountered. To establish a reference, it is only about 1.5×10^{21} angstroms from the earth to the sun. (An angstrom is one ten-billionth of a meter, that is $1/10^9$, and is normally used to measure the wavelength of light.)

The routines provided have been tested using a high-speed line printer as an output device. The routines were fast enough to allow the line printer not to wait when being sent a stream of 6-digit numbers. While the routines have been tested and were fast enough for the desired applications, an extensive effort was not made to eliminate every unneeded processor cycle. The object code provided in listings 1 and 2 will also execute on an Intel 8085 or a Zilog Z80 microprocessor.■

A Quad Terminal Interface

Stephen A Alpert
11 Ridgewood Dr
Auburn MA 01501

Every now and then, a micro or minicomputer owner may be fortunate enough to have more than one terminal and probably a modem or two. Unfortunately, there never seem to be enough interfaces to the computer system to connect all these devices into the system at the same time. This article chronicles my local solution to the problem.

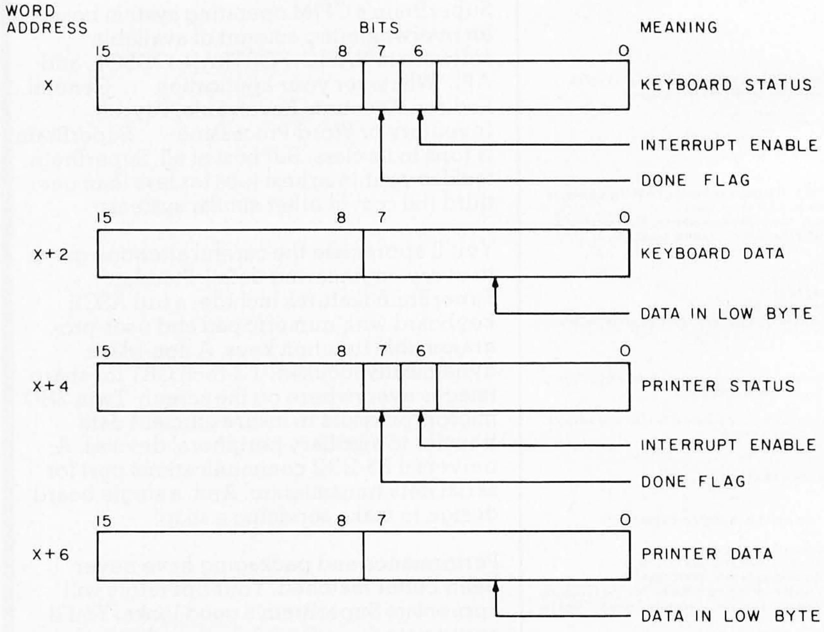


Figure 1: Addresses required for a single terminal are the low bytes of four consecutive words.

- Each terminal requires four words of 16 bits each. The bits in a word are numbered 0 to 15 from right to left. Hence, the low byte in a word contains bits 7 thru 0 and the high byte contains bits 15 thru 8.
- The first word contains only two bits of interest. Bit 7, the most significant bit in the low byte, is the keyboard *done* flag. It is set when a byte is received as input. It is cleared by a bus initialization (BUS INIT) or a processor read of the data. Bit 6 is an interrupt enable bit for the keyboard. When set, an incoming character will cause an automatic vectored interrupt through the processor.
- The low byte of the second word contains the keyboard data.
- The third word is arranged like the first word but is used for the printer side of the terminal. Bit 7 is set by a bus initialization signal (BUS INIT) or when the interface can accept another byte from the computer and is cleared when a byte is sent to the terminal.
- The low byte of the fourth word is the data buffer for the printer.

Table 1: Device addressing organization for interface configuration shown in figure 1.

Through luck and a lot of hard work, my computer system consists of a Digital Equipment Corporation PDP-11/10 processor, a video monitor, a teleprinter, a modem and only one terminal interface. Conveniently, the video monitor, which serves as the main console, is driven directly off the processor. This still meant that there was a deficiency of one terminal interface.

After reviewing the schematic for the interface that I had, I started a design to essentially duplicate that board. A friend jokingly suggested that a design should be generated to drive several terminals at once. Taking that thought seriously, my course of action had been charted.

The creation of this quad terminal interface involves ideas applicable to almost any sort of processor that uses memory addressed IO. That is, the processor contains no special IO instructions, but instead addresses specific memory addresses to communicate with the status registers and buffers of the peripheral devices. This tradeoff means that the devices look like memory and the processor can therefore be equipped with additional instructions at the loss of memory space.

In the case of the PDP-11 series, the processor has a 16 bit data bus and an 18 bit address bus. In this byte addressable machine, the maximum user address space is 32 K words. However, the processor automatically takes all addresses in the range of 160000 to 177777 octal and maps them to 760000 to 777777 octal. (Digital Equipment Corporation uses octal notation in all software.) That means the user memory space is limited to 28 K words with the addresses generated by the processor for 124 K to 128 K specified for the IO page.

About the Author

Stephen Alpert is an associate professor of computer science at Worcester MA Polytechnic Institute. He was the first vice chairman of the ACM's special interest group for minicomputers (SIGMINI) and is a software consultant to Digital Equipment Corporation through Hias Inc. He has owned a minicomputer since 1973.

Stephen wishes to thank R Hully, the president of Hias Inc, for the use of personnel during construction of this equipment.

The organization for the device addressing used on the interface in figure 1 is summarized in table 1. This structure is imposed primarily by the requirement to maintain compatibility with the interfaces supported by the existing software. Essentially, the interface should look to the software exactly like four separate terminal interfaces. A microprocessor could easily utilize this memory layout in consecutive bytes in page zero.

Without the interrupt enable (IE) bit set, the keyboard status register must be constantly checked by the program for the presence of a byte of data. This overhead is wasteful and serves no utility except in the case where the processor has nothing else to do. The processor can acknowledge an interrupt by automatically jumping to a special location in page zero whenever an interrupt occurs. A routine must either poll the individual devices or, via some kind of acknowledge instruction, get information off the bus pertaining to an address of the desired routine or identification of the device requesting the interrupt. This software overhead in a minicomputer makes for very inefficient performance. Also, what happens when more than one device requests service simultaneously? Interrupt masking of some sort is needed. What about a possible priority based on the requests?

The PDP-11 processor eliminates these problems by utilizing hardware priority arbitration and vectored interrupt logic. The processor allows four levels of interrupt requests and a nonprocessor request mode for direct memory access (DMA). Once the processor decides to allow an interrupt request, it issues a BUS GRANT on one of the four lines corresponding to the different interrupt levels. This grant line is fed in sequence from one device to the next. Each device that does not want the grant is responsible for passing it along to the next device as shown in figure 2. In this way, the device closest to the processor always gets the grant first in the case of simultaneous requests on the same line. After the grant has been received by the requesting device, that device is responsible for asserting an interrupt service request and simultaneously asserting a 9 bit address on the data lines of the processor's single bus. The processor will accept this address not as an address of a routine, but rather as a pointer to a pair of words. The first word contains the address of the interrupt service routine and the second word contains a new processor status word. The old program counter and processor status word are saved on the processor's stack. This complete sequencing requires approximately 7 μs in the PDP 11/10.

From the previous discussion, it is apparent that the interface must properly decode 16 distinct word addresses, four for each terminal, along with the proper read or write lines. Furthermore, to eliminate redundant hardware, and save space on an interface board, the logic must do some of its own decoding and encoding of addresses and data. The program counter and

Text continued on page 120

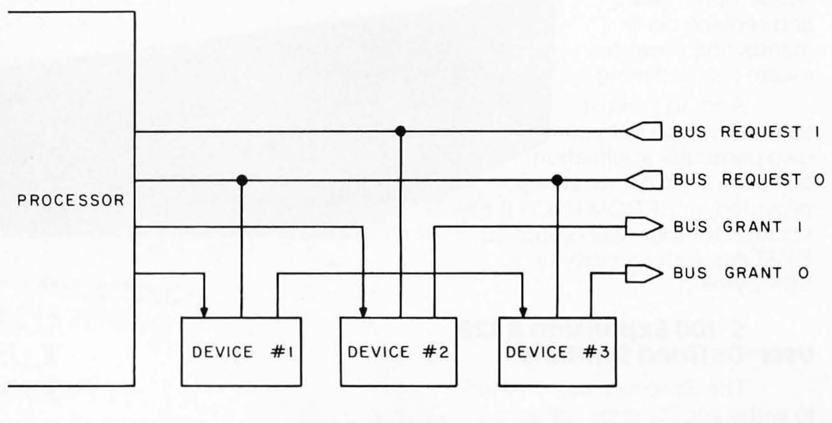


Figure 2: Typical bus request and grant arrangement with two levels. Requests are asserted on a particular request line of the processor. Grants are generated from the processor and daisy chained through the devices associated with that level.

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NUMBER	TYPE	+5V	GND
IC1	74LS266	14	7
IC2	74LS266	14	7
IC3	7410	14	7
IC4	7442	16	8
IC5	7442	16	8
IC6	74148	16	8
IC7	7442	16	8
IC8	74123	16	8
IC9	7438	14	7
IC10	7438	14	7
IC11	NE556	14	7
IC12	7493	5	10

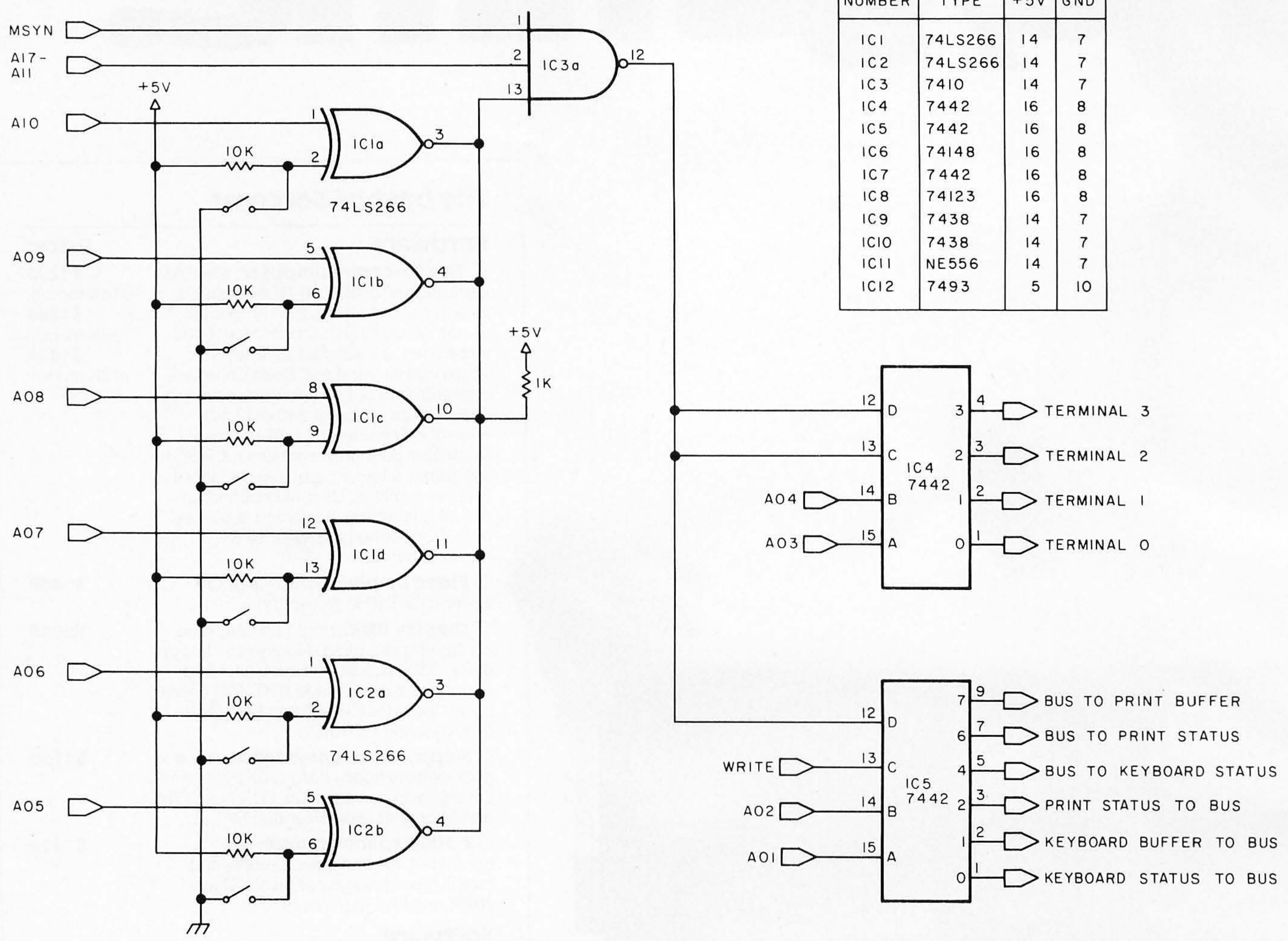


Figure 3: Address decoding circuitry.

Text continued from page 117:
processor status word for the service routines are placed in low memory of addresses less than octal 776 by the software and not by the hardware.

The memory words necessary for this interface will consist of D type flip flops for the status registers since only two bits are needed per word. The input and output data buffers may be hooked directly to the UARTs. UART is, of course, an abbreviation for the Universal Asynchronous Receiver Transmitter, a device which converts parallel bytes of data into a serial stream of bits in an industry standard, time ordered format. The specific UART used in this design is the General Instruments part numbered AY-5-1013.

The address decoding circuitry is shown in figure 3. All signals are conditioned by bus receivers and are not considered valid until the processor asserts a master synchronization signal (MSYN). The 74LS266 is a 4 bit digital comparator with open collector outputs that are "wire ORed" to detect the proper setting of six address lines. The address may be selected by the adjustment of the switches. A pair of 7485 magnitude comparators could have been used in series since they only require a 48 ns delay to compare six bits. The MSYN signal is not asserted until at least 75 ns after the address lines have been activated. Notice the use of two 7442s, binary coded decimal decoders. Since all addresses are in consecutive words, given a base address, say X, the first terminal will use addresses X to X+6, the second terminal will use addresses X+10 to X+16, and so on. IC4 will only assert one of its lower four output lines if the address is in the range for that terminal. IC5 is used with the low address bits and the read or write control lines to indicate which action must be done for the specified terminal. Note that the keyboard data buffer is a "read only" memory and the printer data buffer is a "write only" memory.

The UARTs used in this interface require a transistor-transistor logic load

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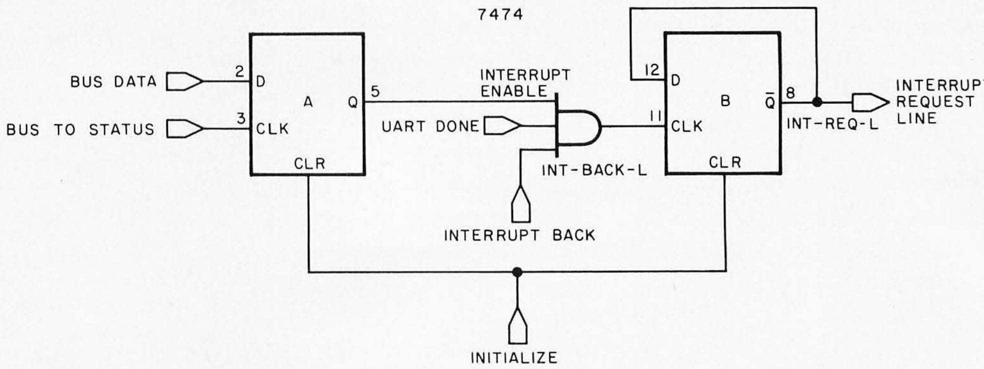
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NUMBER	TYPE	+5V	GND
IC1	7474	14	7
IC2	7411	14	7

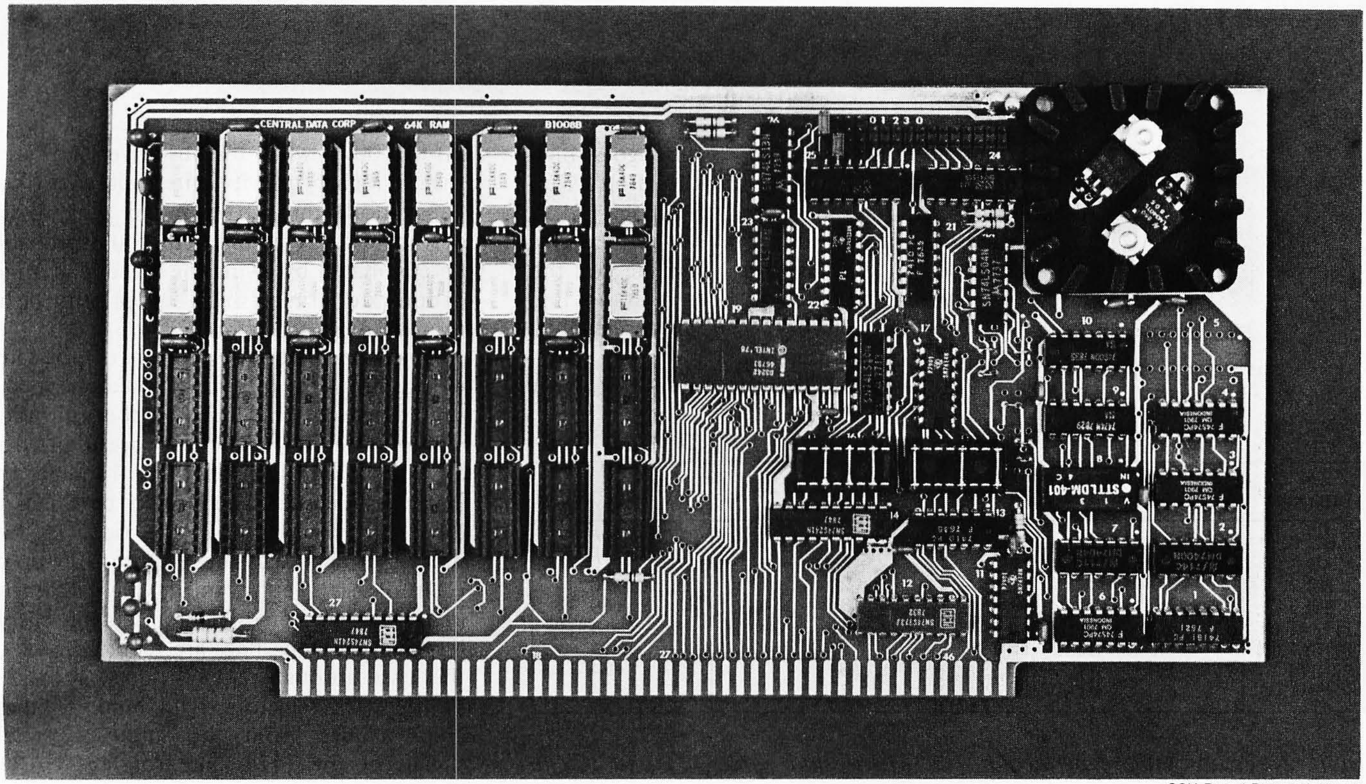
Figure 4: The interrupt logic for each UART consists of a pair of these circuits: one for transmit and one for receive. For the complete interface, eight copies of this circuit are required, so the sections of the 7474 circuits are referenced in text by A and B.

(1.6 mA) for the data inputs and have three state data outputs capable of driving one transistor-transistor logic load. Since the data ports had to be buffered to correctly interface to the processor bus, all input data ports could be wired in parallel and the same for the output data ports. All individual signals to and from each UART must be conditioned via AND or NAND gates to insure communication with the correct terminal unit.

The most difficult task remained: designing the necessary interrupt logic. It was desirable to make the priority of all keyboards higher than any of the printers. This way, no characters would be lost. The inclusion of four terminal drivers on a single board forces a significant increase in the complexity of the interrupt logic.

The interrupt logic consists of two related sections. The first section required properly generating an interrupt from either the input or output side of the UART. Figure 4 shows the circuit for one side of a UART. This circuit appears eight times in the completed board. The interrupt enable bit must have been set through a 7474 flip flop section labeled A in figure 4. Initially, the B section of the 7474 is off so the interrupt request line (INT REQ L) is high and not asserted. Likewise, the interrupt back line (INT BACK L) is high and not asserted. When a character is received (in the case of the receiver side of the UART), UART DONE causes a low to high level transition on the clock input of the B section of the flip flop. Since $\bar{Q}$ was high, D is high and Q is then asserted, making the interrupt request line ($\bar{Q}$) active. This signal then serves as input to the interrupt arbitration logic. The interrupt back line (INT BACK L) will remain high until the actual vectoring takes place. After that, a low to high transition on the interrupt back line will cause the B section of the 7474 to shut off and stay off until either the interrupt enable or the UART done line is cleared and set again. As a convenience, any processor write operation to the status register will also reset the UART making the UART done line wait for the next character to be received.

The interrupt arbitration logic is in figure 5. Interrupt requests are arbitrated by the 74148 8 line to 3 line priority encoder. With the enable input (EI) line normally low, the gate status (GS) output will go low when at least one of the inputs is low, signaling an interrupt request had been posted. The outputs of IC6 will be a binary encoding of the one's complement of the highest priority input signal that is asserted low. When the processor acknowledges the request, the proper vector information, which is made up of a combination of switch settings and 74148 outputs, will be put onto the bus through the 7438 bus drivers. See table 2 for an enumeration of the vectoring. Observe that the bus is at ground potential for an address bit of 1. At the same time, the D3 input to IC7 will go low asserting an output line corresponding to the interrupt. When the interrupt sequence is done, the D3 input goes high and the cor-



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responding interrupt back line goes high clearing its respective D flip flop from figure 4. Simultaneously, IC8 is triggered to time out the gate status output of IC6. This is necessary because the remainder of the interrupt logic requires the gate status line to go high before it can be asserted to request another interrupt.

Unfortunately, there is a period of about 50 to 100 ns when the bus drivers are active that a higher priority interrupt could perhaps sneak through IC6 and deskew the correct data. This problem could probably be eliminated by giving the higher communication rate terminals a higher priority or by using an extra set of latches.

If all the UARTs were driven off the same clock source, the interrupts could only occur simultaneously (in which case the arbitration works correctly) or at least spread apart by an interval equal in length to 16 times the transmission rate. This would be 26 μs at 2400 bps. Feeling that the odds of two people typing two keys within 100 μs of each other is quite small, the circuit remains as presented. The interrupt enable bits and the done flags are reported back to the user through 74153s, dual 4 line to 1 line data selectors. The input to these chips comes from the interrupt enable signals of the 7474s and from the UARTs directly.

Interrupt	74148 Output A2	A1	A0	Octal to 7442	Vector Offset
KBD 0	L	L	L	0	+ 0
KBD 1	L	L	H	1	+10
KBD 2	L	H	L	2	+20
KBD 3	L	H	H	3	+30
PRINT 0	H	L	L	4	+ 4
PRINT 1	H	L	H	5	+14
PRINT 2	H	H	L	6	+24
PRINT 3	H	H	H	7	+34

Table 2: Vector table generated by the 74148 and 7442 (IC1 and IC2 in figure 5) combination through the bus drivers.

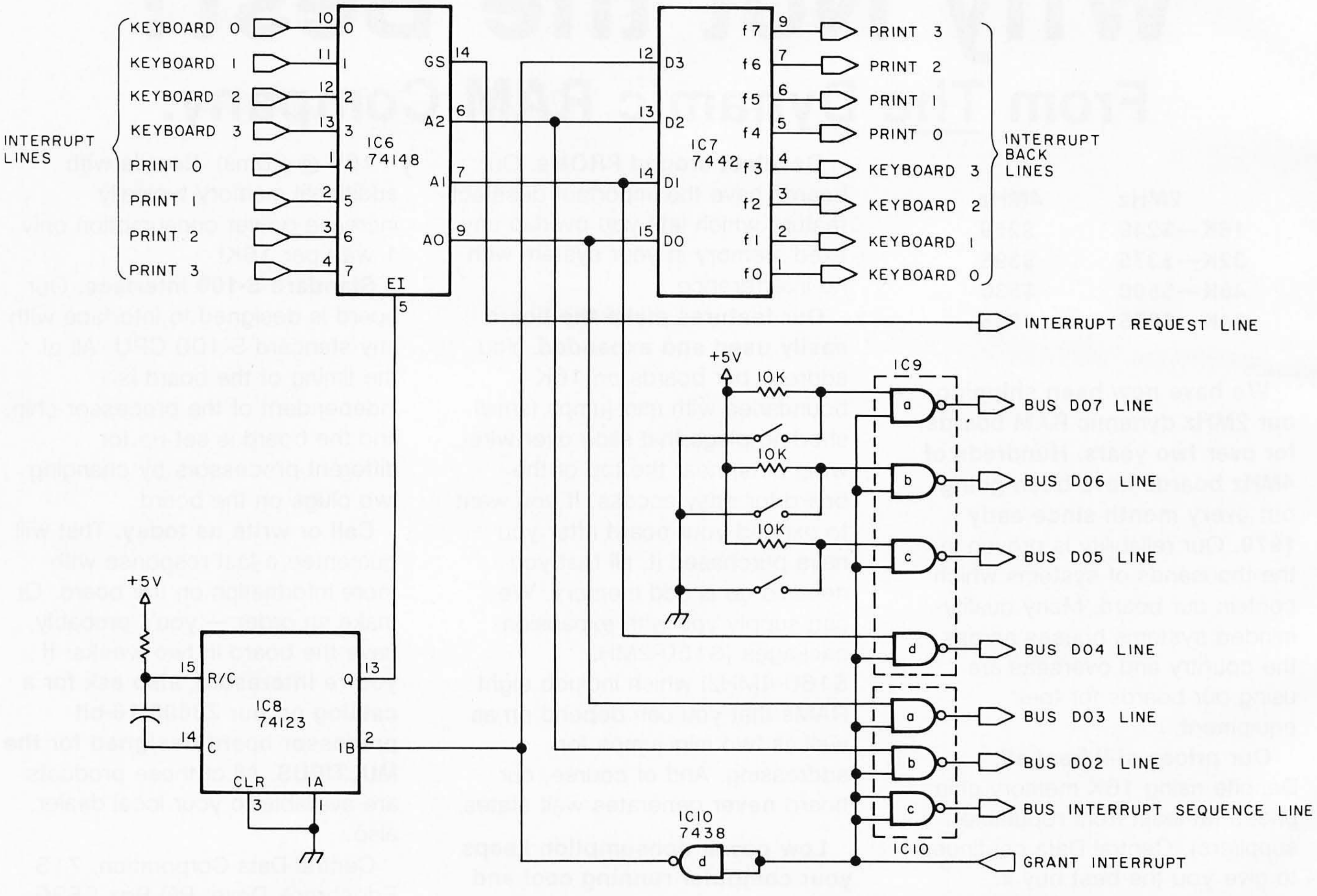


Figure 5: The interrupt arbitration logic interfaces the requests from the UARTs to the remainder of the bus interrupt sequence logic. Note that the 74148s can be wired in serial to control even more requests.

An additional item: in trying to keep my costs to a minimum, my clock driver consisted of an NE556 dual timer and a 7493 divide by 16 counter instead of a MC14411 bit rate generator. Luckily, the NE556 was the only part not in my rather well stocked junk box at the start of this effort. The clock circuit is shown in figure 6. Current market price for four terminal interface boards for the PDP-11 is about $1600. This interface required some four months of spare time to design and debug. The time has been well worth the effort. My 20 mA teleprinter, operating at 110 bps, and my EIA modem, operating at 300 bps, are currently attached to this interface with two ports still open. Now I have a single terminal interface left over with no use for it. I guess I will have to find another terminal.■

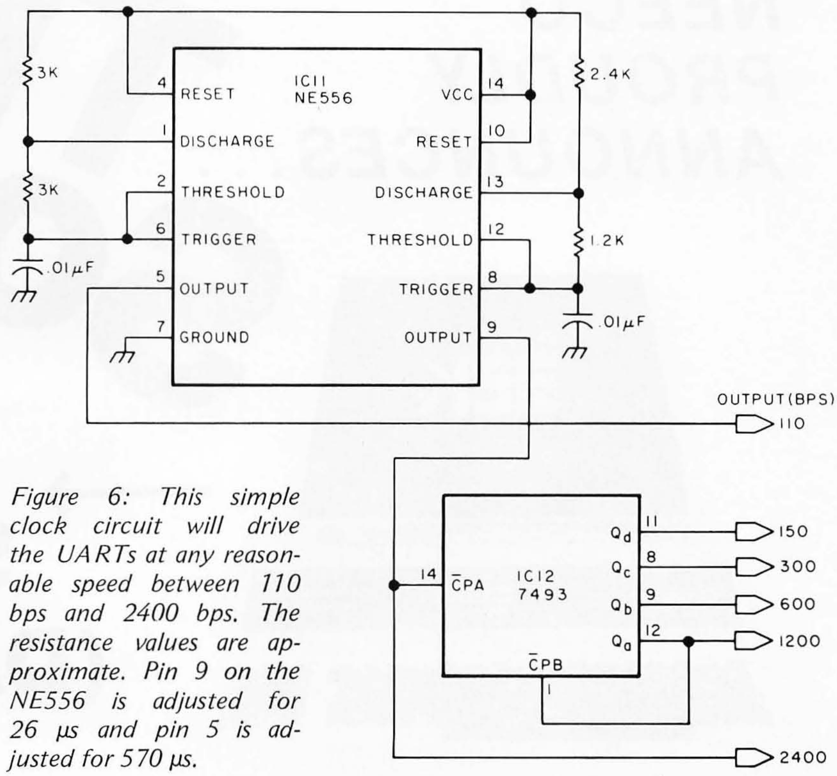


Figure 6: This simple clock circuit will drive the UARTs at any reasonable speed between 110 bps and 2400 bps. The resistance values are approximate. Pin 9 on the NE556 is adjusted for 26 μs and pin 5 is adjusted for 570 μs.

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Comparison of Some High-Level Languages

Robert A Morris
Associate Professor
Department of Mathematics
University of Massachusetts
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Boston MA 02125

Different languages are appropriate for different tasks: multilingual ability is as useful in the computer world as it is in the human world.

The time is not far off when microprocessor users will begin the serious use of high level languages other than the BASIC supplied for many current machines. There are many projects hither and yon to implement contemporary languages in microcomputer form, and the emergence of 16 bit processors will probably accelerate this trend. Indeed, even now microcomputer users have a practical way to use high level languages: using the personal computer as an intelligent interactive editing terminal and sending source code over telephone lines to be compiled and executed by a large remote timesharing computer. For many such tasks, the connection time (the charge levied by the big computer operators for merely listening to your terminal) is a substantial fraction of the total cost. But this time is short compared to the data entry time, which will be entirely on the user's own system.

Unfortunately, most information about languages is gleaned from people who have a stake in a particular language due to a greater familiarity with it. Different languages are appropriate for different tasks. Multilingual ability is as useful in the computer world as it is in the human world. To this end I would like to describe the differences and similarities between major general purpose programming languages, and offer opinions about how these differences might affect your choice of a high level language.

A number of the conclusions I draw can be attributed to questions of style, and many whose personal programming styles are different might take issue or even umbrage at what I offer. Nevertheless, I claim the critical reviewer's prerogative to offer opinion, and hope only that it is clearly identified. One precaution to the novice and to the initiate: In comparing programming languages, I assume that the specific choices are equally well implemented. Unquestionably the worst version of language A may be far harder to use than the best version of language B, even if in principle the opposite is the case.

My own particular bias is that I am not interested in "number crunching": that is, the use of the computer for scientific or statistical calculations which are complex, lengthy (in terms of machine time), and which often run repeatedly with different data. For such so called *production* programs the programming expense is usually small compared with the computing expense, and there is a premium on efficient programs. Suppose one writes a program to solve a system of linear equations by Gauss' method with the principal intention of understanding that method. It then becomes irrelevant that an additional 10 hours of programming effort can produce a 50 percent increase in running speed. The program will run only a few times for a few seconds.

Finally, I admit I am a mathematician. Mathematicians think in unusual ways, especially about computers. I once baffled a computer professional when I told him that most of the programs I write, once written and correct, never needed to be run. Programming as a logical and esthetic discipline is not a very comfortable idea to many professionals. In any case, writing a program in order to understand an algorithm, instead of vice versa, is a commendable use of computers and one which colors my own thinking.

In many organizations some system of phantom money is in effect for computer use. The users and their departments often have budgets but do not spend any money. Rather they simply have some restriction put on their use if this budget is expended. Indeed it has been argued that certain computer use, like library use, should be completely without accounting. Nevertheless, it is common to talk of one or another solution being expensive, and this is to

be understood as being a vague and relative term, taking into account such factors as computing charges, programmer's time and storage charges for data and programs in or outside the machine.

I will discuss essentially three languages: BASIC, FORTRAN, and ALGOL (together with PL/I). I'll also take a cursory look at Pascal and give a brief description of APL together with the reasons for not including it in this survey. These languages are fairly standardized so that if one has learned them on one machine, there is very little relearning necessary for another. Indeed, aside from minor punctuation differences, one rarely encounters machine dependent features of these languages except for input and output (IO). Thus it is often practical to transport programs from one machine to another with very little rewriting except for the IO, but in some circumstances this can be substantial.

Many BYTE readers know BASIC already, but I will describe it so that a broader audience might be reached. In some of the following examples I have abused programming language punctuation in the interest of comprehensibility.

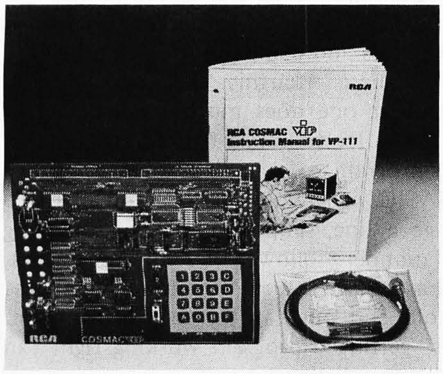
BASIC

BASIC is an acronym for Beginner's All-purpose Symbolic Instruction Code. It was developed originally at Dartmouth University and designed as a conversational interactive language, meaning that the user is essentially in immediate and constant contact with the computer. A good BASIC translator will give some diagnostic messages even as the user types in the program. In any case the system will attempt to indicate to the user the point at which a linguistic error occurs. This is true for most high level languages whether conversational or not, but the conversational feature and the similarity of BASIC to ordinary mathematical notation make it a particularly easy language to learn and use. In fact, it is the language of choice when the program to be written is short, say 20 commands or less, and the manipulation no more than high school algebra. BASIC is typically available on the interactive minicomputers used in many high schools. It looks like this:

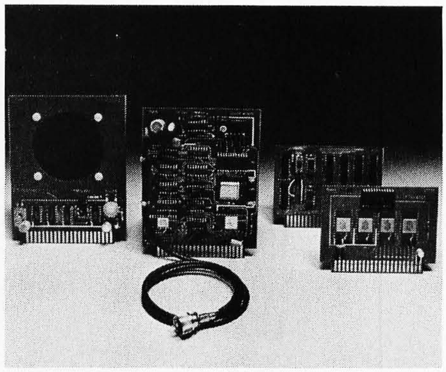
```
100 LET X=Y=3
200 LET Z=5
300 LET W=3*(X+(Y/2))
400 PRINT W
500 END
```

BASIC is an inherently expensive language in terms of time, because it is interpreted rather than compiled. This means that the program is translated into machine

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language each time it is executed, rather than translated once and stored in machine form. The technical differences between interpreters and compilers are not otherwise relevant here. Roughly speaking, with an interpreter one does much less cajoling of the computer to get it to pay attention to one's program.

BASIC programs are easy to alter. To change a line, simply retype the offending line number followed by the new text, then a carriage return. The new line replaces the old and one can try to execute again. Thus, getting a program working right can involve very little waiting.

Many large computers operate in *batch* mode. This means that the user submits the program to the operator, typically on punched cards, and waits for it to be processed in turn. In such an environment the interactive feature is of no use. Although some batch systems have BASIC processors, it seems pointless to use the language this way.

For complicated problems, especially of a mathematical nature, BASIC has some severe deficiencies, even though it is probably the best first language to learn where it is available. One of the biggest of these is the difficulty of writing a BASIC program in pieces. "Passing parameters" can be a very messy business in BASIC and it is usually important to make sure that there is no confusion over the names of the variables. Generally, different variables must have different names, and the same variables the same name throughout a program. Fully-implemented FORTRAN avoids these pitfalls (in a somewhat unnatural fashion), and in ALGOL and PL/I they cannot arise at all. The mathematician's penchant for calling all independent variables t or x may be freely indulged in ALGOL, cautiously so in FORTRAN, and not at all in BASIC. This is particularly important when one is writing general routines to be plugged into several programs which may not have even been conceived yet.

FORTRAN

FORTRAN looks like this:

```
      I=2
      J=3
      K=I+J
      WRITE(6,10) K
   10 FORMAT(I1)
```

The WRITE statement, if mysterious, is at least formal and standard. It instructs the machine to write on output unit 6, probably a printer or the user's terminal, according to format statement 10, the present value of the variable K.

Respectable modern FORTRAN compilers allow the programmer the option of ignoring the format and outputting the results in some standard fashion.

FORTRAN stands for FORmula TRANSlator. It is the oldest and most widely used language for scientific computing. FORTRAN compilers for most machines produce extremely efficient machine language programs because demand is so great and the language has such a long history. For this reason, also, there are many compilers with excellent diagnostic features, such as the University of Waterloo's WATFOR and WATFIV systems available for large IBM machines and even *optimizing* compilers which attempt to improve on the programmer's efforts.

However, as we shall see, some of the classic features of FORTRAN are the very ones that should make people shun it. But because it is so familiar, it is difficult to convince FORTRAN adherents that the language is detrimental to their efforts. Of course, for production programs, efficiency *is* a legitimate reason to use it. Writers of more ephemeral programs should be aware of the extent to which the other languages around them are being improved and be sure the sacrifices are needed. There are two major objections to FORTRAN: it is difficult to write readable programs; and it is difficult to structure programs in a logical way that reflects the programmer's mathematical ideas for the solution of the given problem. I do not claim that these tasks are impossible. But it is widely agreed that typical FORTRAN programs are unreadable. This is often caused by bad habits encouraged by the language. A common experience with large FORTRAN programs is that some months after writing one, even the program's writer must study it at length to find out how it works. For another reader, this job may be immense.

One of the main reasons for this is the way in which logical alternatives are considered and acted upon in FORTRAN (and BASIC, for that matter). One of the principal powers of a computer is its ability to alter its course of action according to conditions that may not be known at the time the program is written, but which may be known only when it is executed. In FORTRAN and BASIC the alternative course of action is numbered (in BASIC all statements are numbered) and a program may contain a statement such as IF (condition to be tested) THEN GO TO 55. If the condition is not met, the computer executes the next instruction, but if it is met it executes the series of instructions which begins with

statement number 55. However, people never think in this way even if the alternative courses of action are too complicated to remember in detail. Instead of bearing in mind *where* the alternatives may be found, one always keeps in mind *what* they are, perhaps in some brief mnemonic form. Thus the ALGOL statement:

```
IF GCD(A,B)≠1 THEN
 P:=SMALLEST.COMMON.PRIME.DIVISOR(A,B)
ELSE
 P:=MIN(A,B)
```

is surely more informative than the FORTRAN version:

```
      IF (GCD(A,B).NE.1) THEN GO TO 55
      P=MIN(A,B)
      GO TO 65
55. . . .code describing how to find smallest
 common prime
65 continuation of program
```

I am not suggesting that ALGOL knows how to find the smallest common prime. Of course, the words SMALLEST.COMMON.PRIME.DIVISOR(A,B) must also be defined in the program, just as they would at line 55 in the FORTRAN program. But the FORTRAN programmer, in the interest of intelligibility, must add comments, both at line 55 and at the appeal to it, telling the reader what is going on. The necessity of adding comments (words which explain the program to the reader but which are ignored by the computer) is a sign that the conventions of human thought have been sacrificed to the conventions of the programming language. This is a common occurrence in FORTRAN and almost impossible to avoid with the use of GO TO statements (see reference 6 for an exposition of this point and its history).

The second mathematical objection to FORTRAN is that dummy variables are somewhat restricted. They occur automatically in subprograms (small portions of a program which are executed repeatedly but each time with different values assigned to their parameters), but otherwise are essentially absent. This means that some care must be taken in writing complicated programs so that variable names are not confused. Because of this it is difficult to transport pieces from one program to another. A skilled FORTRAN programmer told me that his biggest headache is having to constantly rewrite the same algorithm. That favorite phrase of mathematicians "we are done because we are reduced to a previously solved case" is very difficult to put in practice in FORTRAN and BASIC but quite easy in ALGOL and PL/I. FORTRAN subprograms are not recursive. That is, unlike their ALGOL counterparts, they cannot appeal to themselves in their own definition. This subtle difference can have extreme consequences in nonnumeric calculations, but this is beyond our scope.

ALGOL-like Languages

ALGOL is the ALGOrithmic Language developed around 1960 (a standard and quite commonly available version is called ALGOL 60). Originally intended as a language for specifying algorithms for publication, it is now widely implemented and used in scientific environments, especially in Europe. A portion of the language PL/I is similar to ALGOL, and the remarks below generally apply to it. Since PL/I is supported by IBM for its machines far more than is ALGOL, users of IBM equipment may prefer to keep it in mind. Pascal is a kind of second generation ALGOL 60 to which most of the comments in this section apply.

Simple ALGOL appears much like BASIC:

```
BEGIN
   INTEGER X,Y,Z;
   X:=3; Y:=2; Z:=X+Y; PRINT(Z);
END.
```

This program does what the BASIC example does. The differences are in punctuation. ALGOL commands are separated by semicolons, whereas BASIC requires each to have a line number. ALGOL uses the symbol := to assign a value to a variable while BASIC requires the theme LET X=3 (though some versions make LET optional).

Most notable is that the *type* of each variable must be specified; in this example each variable is declared to be an integer. In BASIC no distinction is made between integers and real numbers, while in FORTRAN, if a variable name begins with (usually) I,J,K,L,M or N it is understood to be an integer. Otherwise it is a real variable with some understood accuracy convention (complex variables are also allowed in FORTRAN and most ALGOL implementations). These conventions can be overridden by the programmer, and readability need not be sacrificed in FORTRAN.

One main feature of ALGOL which makes it attractive for mathematical and logical problems is that it is a *block structured* language. By definition a block is a piece of code that begins with BEGIN and ends with END. There may be blocks within blocks nested as deeply as physical limits imposed by the actual computer will allow. Within each block one may declare the names of variables which are to exist only within that block. These variables do not have any existence outside that block and indeed,

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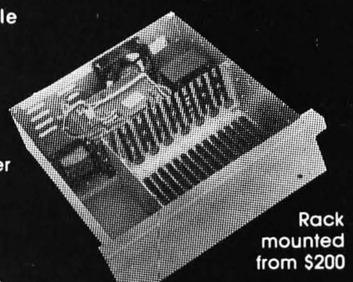
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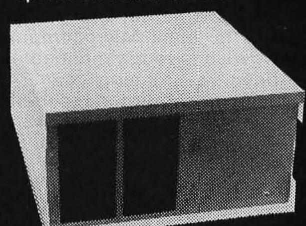
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outside the block there may be other variables with the same name and they will not be confused. Consider the following program:

```
BEGIN
    INTEGER X,Y;
    X:=3;Y:=2;
    BEGIN
        INTEGER X,Z;
        X:=6;Z:=X+Y; PRINT(X);PRINT(Z);
    END;
    PRINT(X);
END.
```

The variable X in the inner block bears no relation to the X in the outer block and references to it in the inner block behave as though there were no X in the outer block. The Y in the inner block, however, has not been declared there, so *it* refers to the next most global occurrence of Y: namely that in the outer block. This program will output:

```
6 8 3
```

The first two numbers are produced by the print statements in the inner block, the last by that in the outer block.

This example is a trivial illustration, but the reader will appreciate that no care whatsoever need be taken with the naming of those variables whose existence is not needed outside the algorithm of which they are part. For this reason, algorithms are easily transported from one program to another. The possible sources of confusion arising from these so called *local variables* are approximately the same as those arising in ordinary mathematical discourse: "the variable *x* here is not the same as the variable *x* in the previous section."

Another feature of ALGOL and PL/I that adds to the ease of structuring programs is the existence of condition testing phrases other than IF. For example, one may use the sequence WHILE . . . condition to be tested. . . DO. . . something. Not only is this close to our way of thinking, but it has surprising implications for the programming solutions which are naturally suggested by the language. Such structures have been urged for FORTRAN and may well be included in future versions. They are beginning to appear in nonstandard versions of FORTRAN already.

What are the disadvantages of ALGOL? Foremost is that even the most commonly used mathematical procedures are often not preprogrammed into the system as they are in BASIC and FORTRAN. Thus, although arrays are a standard data type in ALGOL, there are no matrix manipulation functions such as BASIC's LET MAT A = B + C. The programmer is responsible for adding the routines to perform these operations. Because of the transportability we have

discussed, this is not particularly difficult. In many systems, these routines could be stored on a high speed storage device such as a magnetic disk, easing the task even further. Thus, each programmer or group may have to build a library of standard routines, whereas in BASIC and FORTRAN large libraries are usually already provided.

These functions often include many transcendental functions and sophisticated procedures, but ALGOL libraries may contain little more than elementary functions. This is largely a historical development and may be expected to change as ALGOL becomes more widely used. This drawback is of little consequence if one's application is nonnumeric. At this writing I am programming procedures in ALGOL to calculate with polynomials over finite fields. Since it is too much to expect any library to have a routine to calculate the zeta function of a curve, I am not terribly restricted by the skimpy offerings of ALGOL libraries.

Even more consequential, because of its limited libraries, is the fact that ALGOL tends to require more programming effort for IO than FORTRAN or BASIC. Simply getting numbers in and out is generally easy, but adjusting format or IO of text may be a complicated task. IO is at least standardized, if cumbersome, in FORTRAN and BASIC. However, IO is not part of the official definition of ALGOL, which burdens it with machine dependent features.

Pascal

Pascal is a modern language derived from ALGOL 60 that addresses itself to a very important issue we have not dealt with so far in this elementary exposition: data structures.

Pascal allows the user to define and manipulate new types of data beyond the fundamental types (integers, reals, arrays, strings) which appear in the older languages. Further, it does so in a completely recursive fashion, which adds considerable power to this feature. These matters are beyond the scope of this article, but, as designed, Pascal is easy to learn, powerful and very much like ALGOL in nature.

APL

APL stands for A Programming Language. It is a high powered language designed to make the handling of matrices and vectors particularly easy, and as such it is very successful. Its adherents tend to be emphatic about its value as a general purpose language. My own view is that its array orientation is a disadvantage for structuring complicated

programs unrelated to array handling. The language does not encourage the writing of readable programs. It is easy and tempting to write very compact, cryptic programs (however, this is a human decision and not really forced by the language). The present view of programming languages is that the elementary data and control structures of the language shape the programmer's way of thinking about solutions. Because of its underlying array orientation, I prefer to put APL with special purpose languages and omit it from this discussion, even though it is so widely used that it can not be regarded as an exotic language.

Exotic Languages

A number of special purpose languages and systems have arisen as the result of research in computer languages. An annual survey of languages is published by the Association for Computing Machinery.

Some of these special purpose languages, like the algebraic manipulation systems, may be particularly complex or difficult to use, although appealing to the mathematically inclined. Others, while exciting in prospect, are only beginning to be implemented. Anyone wishing to explore these languages should first gain some traditional programming skill and establish a close relationship with the professionals at the computer center where you are using them, because the exotic products do not always behave as promised and sometimes need a little coaxing from the systems programmers.

Acknowledgements

None of the ideas expressed here is original. They have been percolating in the computer field for a few years, but apparently are still regarded by some as controversial. The names often associated with them are Dijkstra, Wirth, Knuth and Hoare, whose works set them out in detail. I thank Richard Palais for nudging me toward ALGOL and thence to a consideration of these ideas. I wrote this article using a computerized text formatter adapted from the RATFORMATter of Kernighan and Plaugher (see bibliography) who were the first to insist that there is such a thing as literacy in programming.

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Getting Started

The bibliography which follows contains my own favorite introductory texts. Consult local opinion also, because personal explanation is one of the most useful tools in learning programming. If a particular book is highly regarded by people around you, your questions may be more easily answered by others familiar with it. Two other warnings are necessary: you cannot understand programming without writing and running programs; and be wary of the machine manufacturer's language manuals — they are often written for someone who already knows the language or some other high level language. But check them for minor differences with your text. With ALGOL you will probably have to learn the IO from the manual.■

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3. Floyd, R W, *Introduction to Programming and the ALGOL W Language,* Department of Computer Science, Stanford University. ALGOL W is an extension of ALGOL 60 written at Stanford for the IBM 360, and if you have it, you'll find this book particularly useful. If you are adventuresome, consider using it anyway, using the machine manufacturer's manual to sort out the differences. Like McCracken, it's just a beginning.

4. Jensen, K and Wirth, N, *Pascal User Manual and Report, second edition,* Springer-Verlag, New York, 1974. Not a programming primer, but definitely a Pascal primer. A small amount of any programming experience will suffice to read it (an all too brief introduction attempts to substitute for this experience). It also contains the "Report," the official definition of Pascal, which may prove interesting to those who have never seen such a document.

5. Kemeny, J G, and Kurtz, T E, *BASIC Programming,* Wiley, Somerset NJ, 1971. By the fathers of BASIC.

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7. Luehmann, A W, and Nevison, J M, "Computer Use Under a Free Access Policy," *Science,* number 184, May 31 1974, pages 957 thru 961.

8. McCracken, D D, *A Guide to ALGOL Programming,* Wiley, Somerset NJ. The problem with this and other ALGOL primers familiar to me is that they don't really discuss the features of ALGOL that make it powerful. But it is fine for getting started.

9. McCracken, D D, *A Guide to FORTRAN IV Programming,* Wiley, 1972. A widely used text. Included are excellent discussions on points of style and efficiency, and an appendix on the WATFOR and WATFIV compiler. They are often used at universities running IBM systems. They will ease the learning of FORTRAN, as will this book.

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Also see *Communications of the ACM,* volume 19, number 12, 1976.

Some Example Plots

David Dameron 402 E O'Keefe St, Apt 27, E Palo Alto CA 94303

I have been reading BYTE since it was first published in 1975 and have enjoyed its articles, especially those on plotting graphics. My computer is a Cromemco Z80 with 48 K bytes of programmable memory and a 5-inch disk drive. This configuration gives about 20 K bytes of available user memory with 16 K BASIC. My plotter is a Sylvanhills DFT-2, run from a parallel port. I modified the plotter to use stepping-motor X,Y movements, under computer control after reading "Taking the First Step" (February 1978 BYTE, page 35). It now has 300 points per inch of resolution using 15-degree stepping motors.

After the basic vector control software was completed, one of the first routines I entered was a character generator: "A Plot is Incomplete Without Characters" (July 1976 BYTE, page 64). Inspired by "Venus de Plotto" (February 1977 BYTE, cover), I entered various three-dimensional routines, for example: "Hidden Line Subroutines for Three-Dimensional Plotting" (May 1978 BYTE, page 49). You can see that BYTE has greatly contributed to this plotting system.

The three-dimensional plot "Waves" (figure 1) is an example of the hidden line routines. There are 141 points in the X direction and 156 in the Y direction. It is the sum of four radially-damped sinusoidal waves rotated in three dimensions. The program took about 10 hours to run with a 4 MHz clock, divided evenly between point calculation and the actual plotting, which was done concurrently. Listing 1 is a *chord* program which produces the output in figure 2 (page 144).

This sample output took about 90 minutes to plot; a

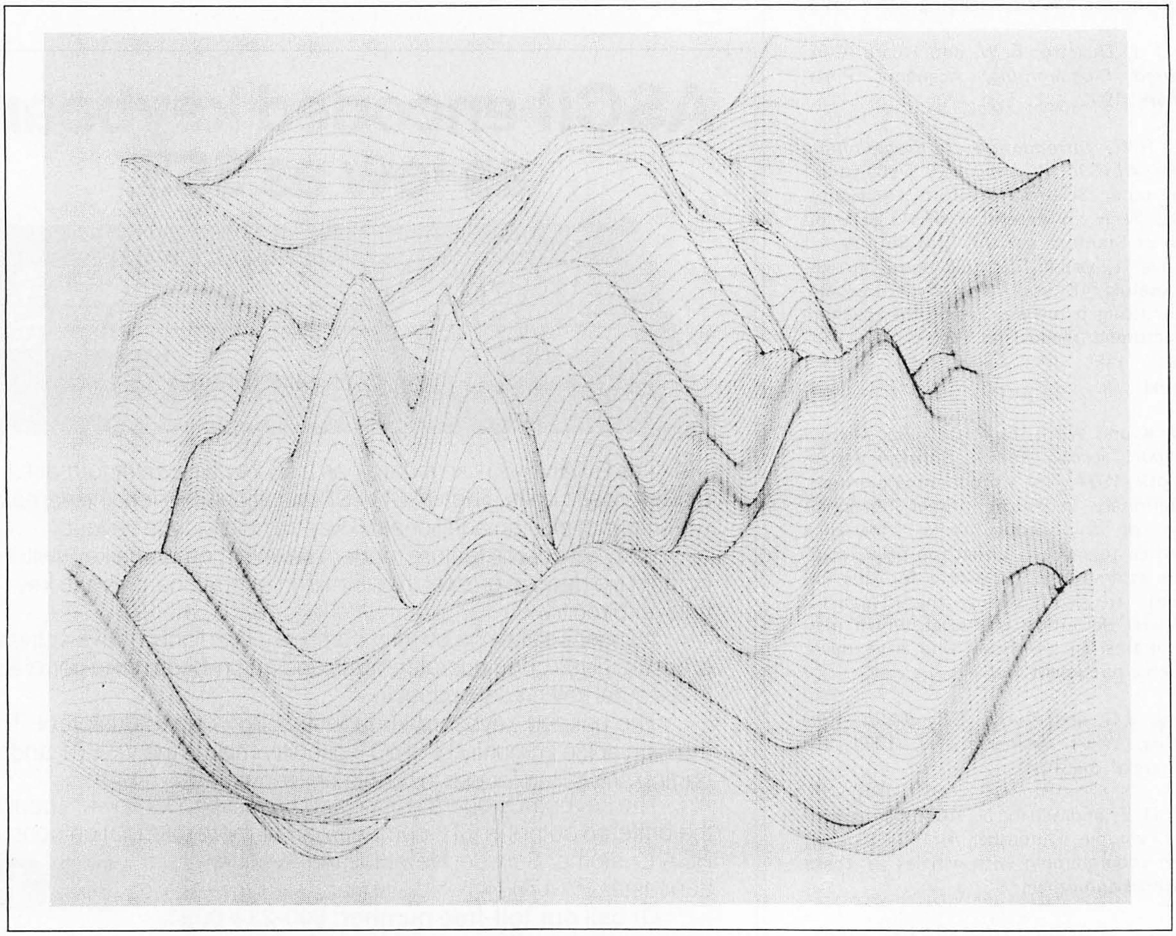
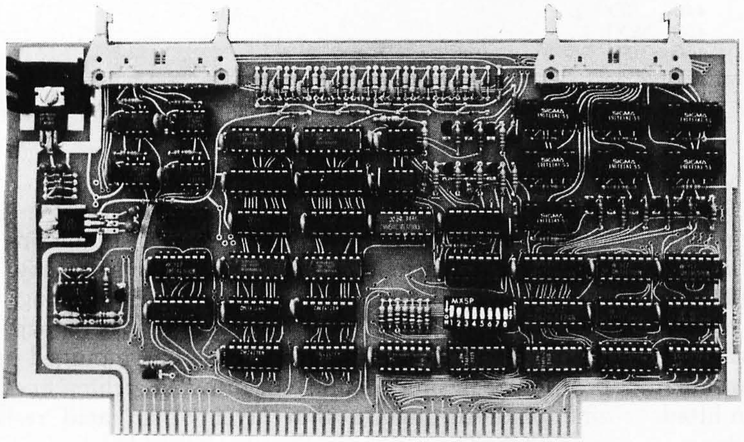


Figure 1: *Three-dimensional wave program output which took 10 hours to produce.*

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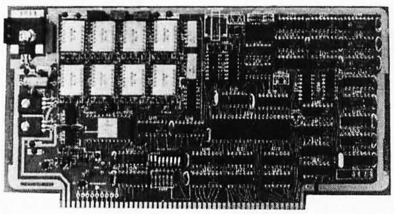
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```
10 REM DRAWS ALL CHORDS WITHIN AN N-GON 7/16/78
20 REM USES DIMENSIONS IN PLOTTER RASTERS
30 REM WRITTEN BY DAVID H. DAMERON
40 REM INITIALIZE PLOTTER HERE.
50 INPUT"NUMBER OF SIDES? ",N
60 DIM B(N),C(N)
70 INTEGER I,J,H(N)
80 INPUT"RADIUS OF PLOT? ",R
90 P1=6.2831853/N
100  FOR I=1 TO N
110  B(I)=R+10+R*COS((I-1)*P1)
120  C(I)=R+10+R*SIN((I-1)*P1)
130  NEXT I
140  FOR I=1 TO INT(N/2)
150  REM DRAW LINES TO I'TH NEIGHBOR
160   FOR J=1 TO N
170   H(J)=0
180   NEXT J
190  IF I<>N/2 THEN 240
200  REM DRAW ONLY 1/2 LINES IF DIAMETERS
210   FOR J=N/2+1 TO N
220   H(J)=1
230   NEXT J
240  J2=1 : F=1
250  N1=N
260  IF I=N/2 THEN N1=I
270  REM J1=FROM, J2=TO POINT
280  REM MAKE J1=PREVIOUS J2 UNLESS TAKEN (H(J1)=1)
290  REM IF TAKEN INCREMENT J1 TILL 1 FOUND, LIFT PEN
300   FOR J=1 TO N1
310   J1=J2
320   IF H(J1)=0 THEN 360
330   J1=J1+1 : IF J1>N THEN J1=J1-N
340   F=1
350   GOTO 320
360   J2=J1+I
370   IF J2>N THEN J2=J2-N
380   H(J1)=1
390   REM F=1 IS A FLAG TO LIFT THE PEN
400   REM IF F=1 THEN MOVE TO B(J1),C(J1) WITH PEN LIFTED
410   REM CALL VECTOR ROUTINE HERE.
420   F=0
430   REM DRAW TO B(J2),C(J2) HERE. INSERT VECTOR ROUTINE HERE.
440   NEXT J
450  NEXT I
460 STOP
```

Listing 1: *Program Chord produces a series of chords for a given circle. The sample output is shown in figure 2 (page 144). This listing was made by the author's system using a plotter.*

little backlash can be seen at the vertices of the 29-sided polygon. The listing was plotted on this system with characters four times the minimum size. This routine was written to remove some of the unnecessary plotter X,Y motion from that of just cycling through all the vertices for both the starting and ending points. Plotter routines should be inserted at lines 390 and 430 to suit a particular system. At 390, move to B(J1), C(J1) with the pen lifted. At 430, draw a line to B(J2), C(J2) with the pen down.

I use the system in my work plotting graphs and other forms of data, and I hope to eventually sell some of the computer graphics I have produced. It is stimulating and fun to create various plot outputs on the spot, now that the hardware has been debugged and is running. The plotter output is not limited to ink drawings on paper. A needle or other engraving point may be mounted in the pen holder (a small clamp) for drawing etching lines in a zinc plate through a thin layer of an acid resisting substance. The plots can then be etched by dumping the plate in an acid bath for an appropriate time period.

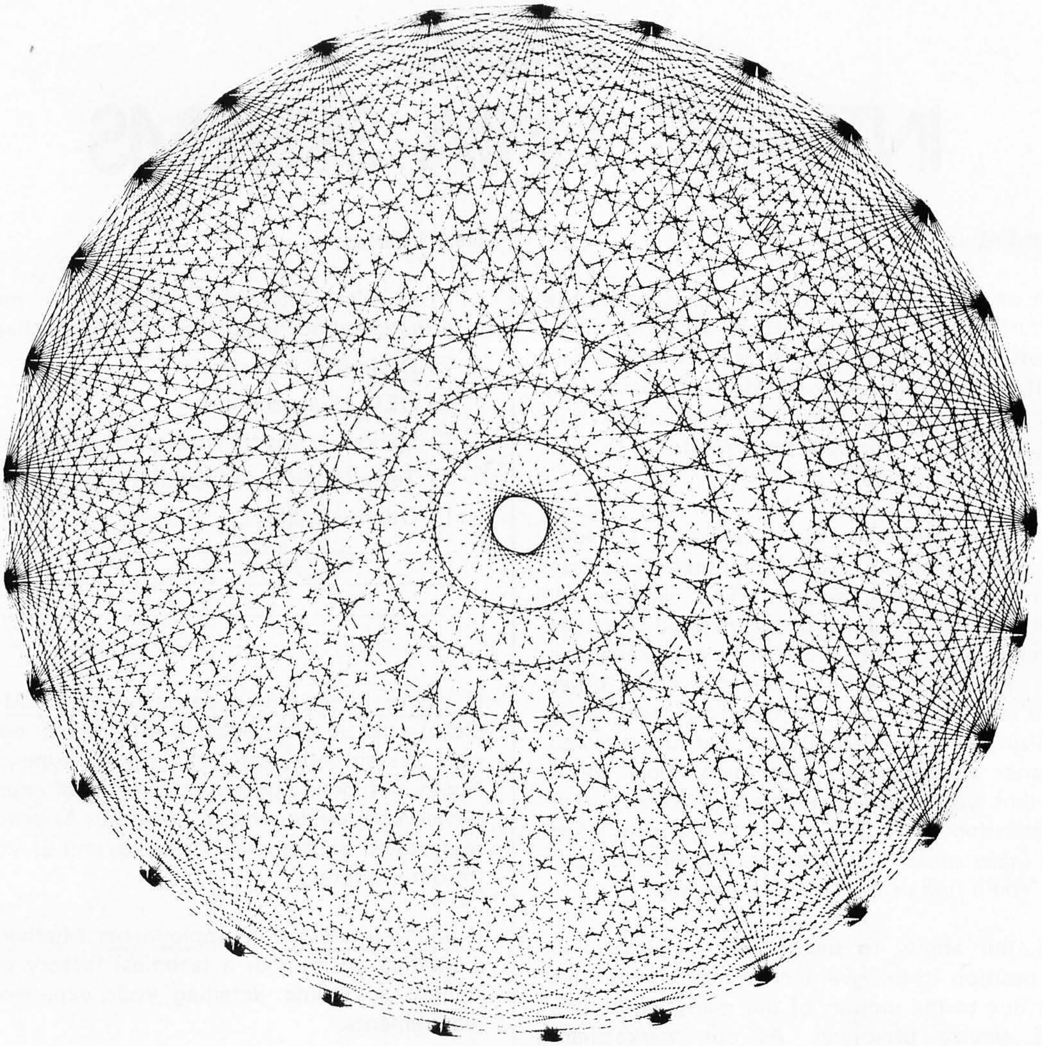


Figure 2: *Sample output of the Chord program written in BASIC. This figure took 90 minutes to produce.* ■



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Technical Forum

Introduction to Code Tightening

Geoffrey Gass, 5240 SW Dosch Rd, Portland OR 97201

"Why should a programmer be so obsessed with pinching and scraping to save a few bytes of code?" asks the representative from Behemoth Computers Inc. In his part of the universe, whether a program takes 110,000 bytes or 120,000 bytes is of no particular moment.

"What a damned tangle!" echoes one of his customers. "Haven't they ever heard of top down programming?" His part of the computer universe is concerned with programs written and understandable by interchangeable programmers, so any new job applicant capable of peeling his own bananas can pick up where the last programmer left off at the time of his unfortunate starvation.

In a smaller part of the universe occupied by minicomputer users and programmers, "tightening up the code" very early became a necessary practice to get useful programs into more confined memory spaces.

An even cozier corner, of course, is that of the personal computer programmer, who may have to spend many hours in tightening, trimming and squeezing to get a couple of quarts of program into his one-quart memory.

The tightest quarters of all (they might be described as "two-by-two by you") are those occupied by the microprocessor programmer fitting useful programs and modules into read-only memories (ROMs) for dedicated systems or monitors. Read-only memories come in relatively small, fixed sizes. The first estimate of what can be done in a given size read-only memory is always excessive of course, but in any typical project the absolute hardware limits are set very early, and it's up to the programmer to get as many as possible of the originally promised features into the fixed module size.

If by chance there are a couple of no-operation instructions (NOPs) in the final coding, then there is immediate pressure to do some tightening and squeezing to add another feature or two. If, as is more probably the case, the first coding runs long, then there is more intense pressure to squeeze, pare, tighten and rewrite every conceivable way to get the program genie into the bottle. (Even if the hardware decision is reversed and the read-only memory space doubled, program expectations will be increased until they again overflow the assigned space. This is a corollary of Parkinson's law; it is amply verified.)

The successful programmer in this environment is the one who gets the job done. It takes a substantial repertoire of techniques and a good eye for spotting loose coding and redundant logic to do a succesful job of fitting the required functions into a fixed domain of memory. Though he may earn the scorn of the Behemoth man

("cheese-parer!") and the bitter enmity of the user who wants to reach in and borrow some of his subroutines, he wins in the marketplace when his product does more for less money, weight, power or space (or simply gets to the market sooner because of fewer hardware redesigns in the development cycle).

The object of this discussion is to present some of the tricks of the programmer's trade by which redundant logic and loose code can be tightened up to get maximum function into minimum memory space. But please heed the warning note at the end, lest you get yourself into a cleverness box from which there's no escape!

Redundant logic can be illustrated by the following sequence:

```
CMPA    #20       Compare ACCA to the value 20.
BMI     CODIN     Less than 20? Go to CODIN.
BEQ     DELIM     Equal to 20? Go to DELIM routine.
BGT     TEXTIN    Over 20? Treat as text input.
```

Obviously, the last instruction is redundant. If the accumulator is not less than or equal to 20, it must be more than 20, and the third test is unnecessary. Frequently, the redundancy is more subtle, being determined by external parameters which make certain conditions impossible, and therefore unnecessary to test for.

Loose coding may be illustrated by this nice, straightforward top down subroutine for a 6800 string print operation:

```
PDATA    LDAA   0,X      Get data byte per index register.
         CMPA   #04      Check for EOT (string terminator).
         BEQ    EXIT     If EOT, return to calling program.
         JSR    OUTEEE   Not EOT. Output this character.
         INX             Step index register to next loca-
                         tion.
         BRA    PDATA    Go back for next byte.
EXIT     RTS             Return to calling program.
```

The routine uses 13 bytes. The sharp programmer notes immediately that it has two branches in it, one of them unconditional. An unconditional branch is always somewhat suspect in itself; in a short routine already containing a conditional branch, it's doubly suspect.

Here's how Wiles and Felix optimized the routine in Motorola's MIKBUG read-only memory. By moving the entry point to the middle of the routine, the unconditional branch can be thrown out and the loop closed by the conditional branch alone:

```
PDATA2   JSR    OUTEEE   Output the character.
         INX             Step to next location.
PDATA1   LDAA   0,X      Enter here. Get character per XR.
         CMPA   #04      Check for EOT.
         BNE    PDATA2   If not EOT, output the character.
         RTS             Was EOT. Return to calling pro-
                         gram.
```

Now we are down to 11 bytes. To save even more, the system could be changed to use 00 (NUL) rather than 04 (EOT) as the string terminator symbol. Because the N and Z bits of the condition code register in the Motorola 6800 respond automatically to a LOAD operation (this is *not* true of the 8080 and some other processors; you have to know the fine print to do a good job of code tightening), the comparison can be thrown out:

```
PDATA2   JSR    OUTEEE   Output the character.
         INX             Step to next.
PDATA1   LDAA   0,X      Enter here. Get character per XR.
```

```
        BNE     PDATA2  Not 00? Output it and get next.
        RTS             Was 00. Return.
```

Now, the job is all done in nine bytes, a 30 percent saving in code. (This trick could not be used in MIKBUG, since some of the strings contained NULs.)

For the read-only memory programmer, that could mean the difference between fitting and not fitting the allocated hardware. For the home hacker who hand-assembles his code it could be the difference between rewriting these few bytes and rewriting several pages of code (and risking a blowup if an address or offset is overlooked). It's not hard to guess which approach is best!

A Word of Warning

Here's a word of warning though: if you learn a lot of tricks and start applying them all in your original coding, there will be nowhere to tighten up if you run over. Your coding will also be much harder to understand later when you want to do something slightly different with it.

It's a little pathetic to see a routine loaded with twists, kinks, and convoluted logic, followed by a string of NOPs, revealing that the programmer was just performing logical games for his or her own amusement, or else swiped the routine from someone else without understanding it!

So, the best programming practice is to go with relatively loose and straightforward top down programming in the initial approach to a problem, and to save the tricks until you really need them. ■

Mining the Skip Chain for Extra Bytes of Code

Geoffrey Gass, 5240 SW Dosch Rd, Portland OR 97201

Need bytes? Go where the code is, and start prospecting.

Somewhere, a program will probably be checking a value or input against several reference values, performing various actions according to the results of comparisons. A common filter construction uses a *skip chain*, a procedure which gobbles up a lot of code. This is therefore a good place to start a mine, smelter and refinery.

A typical skip chain might look like this (coding is for the Motorola 6800, but the process is essentially the same for all machines):

```
CTRL1   CMPA    #$18    Check for CANcel.
        BNE     CTRL2   Not CAN? Skip next.
        LDX     BUFAD   Was CAN. Get start point.
        STX     BUFLOC  Reset "current" location.
        BRA     BUFIN   Go get revised data.
CTRL2   CMPA    #$0F    Check for CTRL/0 (backspace).
        BNE     CTRL3   Not CTRL/0? Skip the following.
        CPX     BUFAD   Was CTRL/0. Check current posi-
                        tion in buffer.
        BEQ     BUFIN   At start? Can't backspace. Forget
                        it.
```




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```
        DEX                 OK for backspace. Step back 1.
        STX      BUFLOC     New "current position."
        BRA      BUFIN      Go get corrected input.
CTRL3   CMPA     #$12       Check for CTRL/R (restart).
        BEQ      LININ      CTRL/R? Start all over.
        BRA      BUFIN      All others, back to BUFIN.
```

There is nothing seriously wrong with the routine as shown, but it uses up 29 bytes in making three comparisons, and all of the operations but one end up by branching to BUFIN. Two of the BRA BUFIN instructions are unnecessary. Since all of the tests are for *equality*, the quantity in A is obviously going to match at only one test. So why bother jumping out early to avoid the other tests?

Another redundancy in this particular instance is not quite so obvious unless you see the rest of the routine. Note that in the CTRL2 sequence, a backspace is performed by decrementing the index register and putting the index register value into BUFLOC. Evidently, the index register carries the "current position" and is equal to BUFLOC when first entering the routine. There are two STX BUFLOC instructions in the routine. Could they be consolidated? The answer is yes, if we do not mind stuffing the index register into BUFLOC for all incoming codes. Try this:

```
CTRL1   CMPA     #$18       Check for CAN.
        BNE      CTRL2      Not CAN? Skip.
        LDX      BUFAD      Was CAN. Change XR content.
CTRL2   CMPA     #$0F       Check for CTRL/0 (backspace).
        BNE      CTRL3      Not CTRL/0. Park XR and check
                            for CTRL/R.
        CPX      BUFAD      Check position.
        BEQ      CTRL3      At start? No backspace. Drop on
                            through.
        DEX                 Step back 1.
CTRL3   STX      BUFLOC     New or old XR value.
        CMPA     #$12       Final test, for CTRL/R.
        BEQ      LININ      If CAN or CTRL/0, will fall through.
        BRA      BUFIN      All except CTRL/R, back to
                            BUFIN.
```

Now the routine is down to 23 bytes: possibly a significant saving in a program being squeezed for memory space.

Note that what we are doing here is to trade redundant code for redundant operations, a frequently encountered tradeoff. To save a few bytes of code we have stretched execution time significantly. For keyboard interactive routines (as in the example), the execution time is unimportant. In a much used mathematics subroutine on the other hand (eg: multiple precision add or multiply), execution time will be much more important, since the subroutine may be called thousands of times in one calculation, and an optimum tradeoff would be more likely in the direction of code redundancy to gain speed of execution (counting machine cycles, not bytes of memory).

The next time you are squeezed for space, and speed is not critical, take a look at your skip chains: they may be able to furnish all the bytes you need, with a little refining. ■

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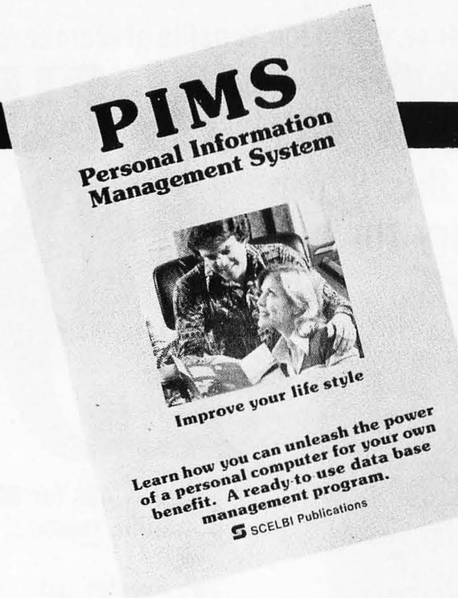
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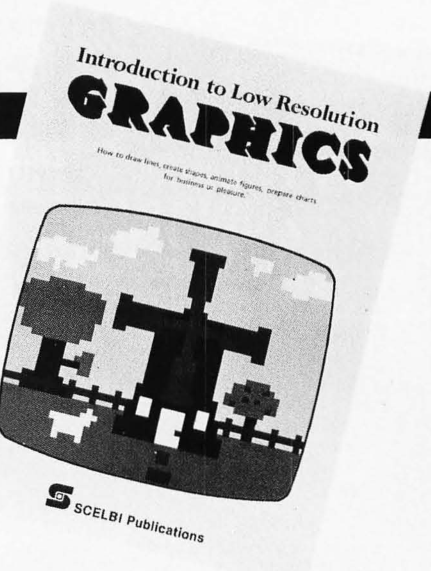
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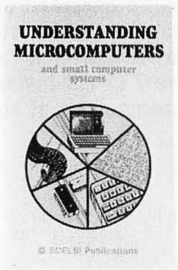
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Event Queue

FEBRUARY 1980

February 6

Invitational Computer Conference, Ft Lauderdale FL. This conference is directed to the quantity buyer and will feature the newest developments in computer and peripheral technology. Contact B J Johnson and Associates, 2503 Eastbluff Dr, Suite 203, Newport Beach CA 92660.

February 12-14

Data Communications Conference and Exhibition, Harbour Castle Hilton, Toronto Ontario, Canada.

Panel sessions, presentations, workshops, and technical sessions related to the field of data communications will be featured. Network control, management, performance and architecture; communications hardware and software; fiber optics; distributed data processing; and international communications policies are some of the subject areas that will be discussed.

The exhibition at the convention center will feature over 100 exhibitors.

For more information, contact Whitsed Publishing Ltd, Suite 2504, 2 Bloor St W, Toronto, Ontario M4W 3E2 CANADA.

February 11-13

Programming the 6502 in Machine and Assembly Language, George Washington University, Washington DC. This course is aimed at engineers, scientists, mathematicians and students who need to learn how to develop special-purpose microcomputer systems for their own use. Familiarity with FORTRAN or BASIC will be helpful. For more information, contact Director of Continuing Engineering Education, George Washinton University, Washington DC 20052, (202) 676-6106.

February 11-13

Configuration Management, George Washington University Washington DC. The objectives of this course are to review the impact of latest Department of Defense directives and instructions in the configuration management (CM) area; explain policy for practical applications; and clarify the role of CM in meeting program/project objectives. Engineers, program managers, production, quality control, and purchasing people are invited to attend. Familiarity with the contents of MIL-STD-480 is a prerequisite. Contact the Director, Continuing Engineering Education, George Washington University, Washington DC 20052, (202) 676-6106.

February 13-15

The IEEE International Solid State Circuits Conference, San Francisco CA. This conference is a forum for the presentation of advancements in every aspect of solid state circuits. It will cover design, performance, fabrication, testing, and applications in digital, analog, microwave, and other areas of new solid state circuits, device structures, phenomena and systems. For more information, contact Lewis Winner, 301 Almeria Ave, POB 343788, Coral Gables FL 33134.

February 18-21

European Information Management Exhibition and Conference, Wembley Conference Centre, London England. This show will exhibit microcomputer systems and peripheral items with demonstrations and applications focused on problem solving for the management executive. Contact Expoconsul, 420 Lexington Ave, New York NY 10017.

February 22-23

Louisiana Computer Exposition, University of Southwestern Louisiana, Lafayette LA. This conference is entitled "Distributed Systems Based on Mini and Micro Computers." It will cover programming languages, operating systems, evaluation of distributed systems, design criteria for distributed systems, and other related topics. There will be exhibitions of equipment and papers will be read and discussed. For more information, contact the Computer Science Dept, University of Southwestern Louisiana, POB 44330, Lafayette LA 70504.

February 25-27

Communication Networks '80, Shoreham Americana Hotel, Washington DC. This conference and exposition

In order to gain optimum coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, 70 Main St, Peterborough NH 03458. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

will cover business communications. For program information, contact the Director of Program Development, The Conference Company, 60 Austin St, Newton MA 02160. For exhibit information, contact the national sales manager, Communications Networks '80, POB 96, Haddon Heights NJ 08035.

February 25-27

3rd International Learning Technology Congress and Exposition, Sheraton Washington Hotel, Washington DC. Applications and technologies for the use of microcomputers and video disks as well as traditional technological issues in education and training will be discussed. In addition to the technical sessions, exhibits will range from video disk and media-based systems to computer-based instruction systems. Contact the Society for Applied Learning Technology, 50 Culpeper St, Warrenton VA 22186, (703) 347-0055.

February 25-27

Microprocessor Peripherals Workshop, Montgomery AL. This hands-on workshop includes 27 hours of instruction, with a take-home option and one microcomputer station for every two participants. Contact Paul A Willis, POB 29, Arlington VA 22210.

February 25-28

Compcon '80, Jack Tar Hotel, San Francisco CA. The conference theme is "VLSI: New Architectural Horizons." It will be devoted to developing advanced technologies for computers. Contact Compcon Spring '80, POB 639, Silver Spring MD 20901.

February 26-28

Nepcon West '80, Anaheim Convention Center, Anaheim CA. The conference and exhibit will deal with the latest advances in electronics by covering such topics as wave soldering, etching, automated assembly, die attaching, hybrid circuit packaging, photo lithography, precious metal recovery, laser annealing, and much more. For further information, contact ISCM Inc, 222 W Adams St, Chicago IL 60606.

February 26-29

Office/Korea/80, Korea Exhibition Center, Seoul Korea. Exhibits at this exposition will include the range of products needed in offices from computers, word processing equipment and software to stationery, supplies, furniture and services. Information about the show may be obtained from Expoconsul, a division of Clapp and Poliak, 420 Lexington Ave, New York NY 10017.

February - August

Microprocessor Design Courses. The course is aimed at professional design engineers and covers fundamentals of microprocessor operations, programming, architecture and input/output integration. It will also cover Z80 and 8085 processors, working with the STD BUS and the designing and documenting of software. Tuition for the course is $400. The courses will be held in major cities throughout the US. Contact Elma Barnes, PRO-LOG, 2411 Garden Rd, Monterey CA 93940, or phone (408) 328-4745.

MARCH 1980

March 1

Exploring Small Computers,

Albion College, Albion MI. This fair will feature exhibits and seminars on microcomputers and their applications in business, education, and the home. Contact D W Kammer, Dept of Physics, Albion College, Albion MI 49224.

March 3-5

Office Automation Conference, Georgia World Congress Center, Atlanta GA. A combination conference and exhibition of office computer systems has been developed to help management understand the growing technology of business computer systems. For more information, contact H A Bruno and Associates Inc, 78 E 56th St, New York NY 10022.

March 4 and 5

8th Annual Midwest Digital Equipment Exhibit and Seminar, Thunderbird Motel Minneapolis MN. Manufacturers of computer terminals, data communication equipment, peripherals, data acquisition systems and digital test instruments will display their products. Seminars will be held both days. For further information, contact John Bastys Countryman Associates Co, 1821 University Ave, St Paul MN 55104.

March 6-8

Microprocessor Peripherals Workshop, Chattanooga TN. See February 25-27 for details.

March 10-12

1980 National Office Exhibition and Conference, Automotive Building, Exhibition Pl, Toronto Canada. Subject areas of the conference will include energy conservation, small business computers, micrographics, word processing, telecommunications, copiers, office landscaping, and many others. There will be approximately 100 exhibitors presenting their products and giving demonstrations.

For more information, contact Whitsed Publishing Ltd, Suite 2504, 2 Bloor St W, Toronto, Ontario M4W 3E2 CANADA.

March 14-16

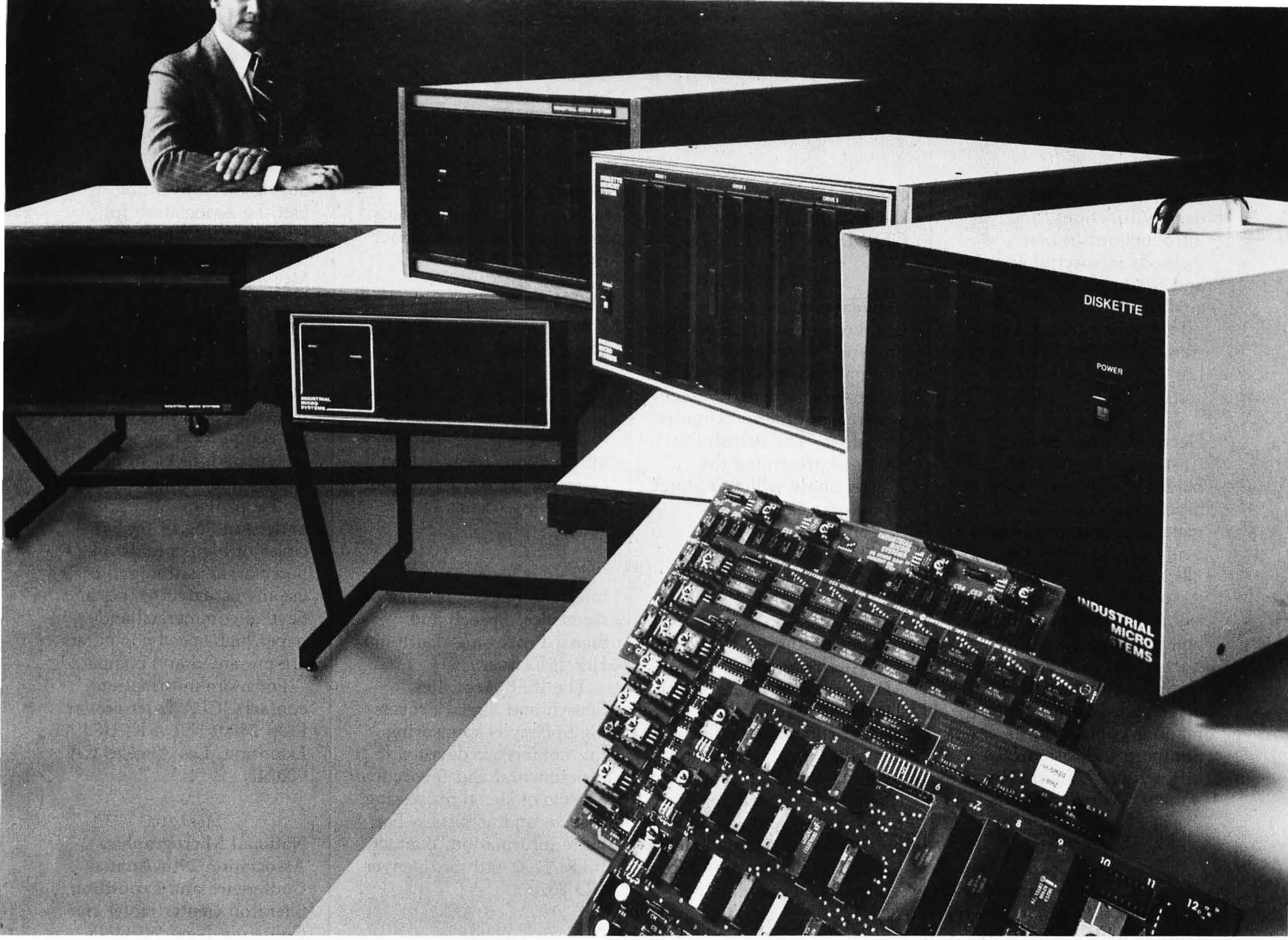
West Coast Computer Faire, Civic Auditorium and Brooks Hall, San Francisco CA. An expected 15,000 attendees, over 340 exhibits, and more than 100 conference speakers will highlight this year's program. Exhibitor and speaker information may be requested from the Computer Faire, 333 Swett Rd, Woodside CA 94062.

March 17-20

Interface '80, Miami Beach Convention Center, Miami Beach FL. This conference and exposition is devoted to data communications, distributed data processing, and networking. Approximately 1000 exhibitors are anticipated and attendance is expected to exceed 12,000. For information, contact Interface '80, 160 Speen St, Framingham MA 01701.

March 17-21

Applied Time Series Analysis, University of California at Los Angeles CA. This course is designed for engineers, scientists, programmers, economists and other users of digital time series who require modern methods of data analysis using the fast Fourier transform (FFT), digital filtering, power spectral densities and correlation functions. The lectures cover topics relating to the Fourier transform, sampling linear systems, convolution, covariance, digital filtering,



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March 20

Electronic Road Shows, Castaways Restaurant, Burbank CA. This traveling exhibition of components, materials, and instruments is being produced by the Electronic Representatives Association (ERA). Over eighty ERA member firms will participate, and products from over 700 electronic companies will be displayed. For more information, contact the Southern California ERA office 20969 Ventura Blvd, Suite 9, Woodland Hills CA 91364.

March 24-26

Data Entry Management and Supervision Seminar, Cherry Hill NJ. This course deals with the practical aspects of data entry, and the problems encountered that are common to supervisors and managers. Concepts, techniques, motivation, training, and productivity will be covered. The fee is $415 for subscribers of MIC publications and $445 for nonsubscribers. For more information, contact MIC, 140 Barclay Ctr, Cherry Hill NJ 08034.

March 24-28

Fourth European Conference on Electrotechnics, Stuttgart. This conference will review recent developments, trends, and applications in the field of microelectronics. Microprocessors, computer communication, industrial electronics applications of microelectronics in the automobile and in medicine, and other topics will be covered. The conference language will be English. Contact Professor Dr W E Proebster, IBM Deutschland GmbH, Postfach 80 08 80, D-7000 Stuttgart 80 GERMANY (BRD).

March 26-28

Viewdata '80, Wembley Conference Centre, London England. Viewdata 80 is an international exhibition and conference on video-based systems and microcomputer industries. The British Post Office is presenting the Prestel Show which is about electronic mail services.

Contact TMAC, 680 Beach St, Suite 428, San Francisco CA 94109.

March 30

Greater Baltimore Hamboree and Computerfest, Maryland State Fairgrounds, Timonium MD. Personal, dealer, and small business computer displays and exhibits will be featured. Space is available outside for tailgate sales and swaps. For more information, contact Joseph Lochte Jr, 2136 Pine Valley Dr, Timonium MD 21093.

March - June

Computer and Office Systems Expo and Conference. This is an exposition for marketers of office systems equipment. The show and conference will focus on the local problems and opportunities of each region. The exposition and conference will be held in major cities around the nation. Contact The Conference Co, 60 Austin St, Newton MA 02160, or phone (617) 964-4550.

APRIL 1980

April 1 and 2

Southeast Printed Circuits and Microelectronics Exposition, Sheraton-Twin Towers Convention Center, Orlando FL. This show is a specialized event devoted entirely to the packaging, production and testing of printed circuits, multilayers, semiconductor devices, and hybrids in the Southeast. Conferences are aimed at electronics specialists. Contact ISCM, 222 W Adams St, Chicago IL 60606.

April 9-11

The Practical APL Conference, Washington DC. This conference is addressed to business executives and systems designers. For more information, contact Joan Gurgold, STSC, 7 Holland Ave, White Plains NY 10603.

April 9-11

International Conference on Acoustics, Speech and Signal Processing, Fairmont Hotel, Denver CO.

The IEEE Acoustics, Speech and Signal Processing Society is sponsoring this conference devoted to experimental and theoretical aspects of signal processing, speech, and acoustics. For more information, contact IEEE, 1100 14th St, Denver CO 80202.

April 11-12

10th Annual Virginia Computer Users Conference. This conference is sponsored by the Virginia Tech ACM student chapter. The topics of discussion will be programming languages and system and personnel management. For more information, contact VCUC10, 562 McBryde Hall, VPI&SU, Blacksburg VA 24061.

April 13-16

A Gateway to the Use of Computers in Education, Chase Park Plaza Hotel, St Louis MO. The purpose of this convention is to provide a forum for the exchange of information and ideas between individuals, to inform educators of developments in computer technology, and to expose participants to innovations in computing which can be utilized in the field of education.

Educators are encouraged to exhibit and make presentations of instructional microprocessor materials during the convention. Contact the Association for Educational Data Systems (AEDS), POB 951, Rolla MO 65401.

April 14-18

High-Speed Computer Organization, 6266 Boelter Hall, UCLA Extension, Los Angeles CA. This course is for computer designers, system architects, project leaders and managers. The course provides an understanding of the principles of high-speed computer organization and their use in cost-effective systems. Several commercial and paper high-speed computers are presented and compared.

For more information, contact UCLA Extension at POB 24901, Dept K, UCLA Extension, Los Angeles CA 90024.

April 21-25

National Micrographics Association 29th Annual Conference and Exposition, Sheraton Center Hotel and Coliseum, New York NY. The theme for the show is "Focus on Productivity in Office Management." Highlighting the conference and exposition will be presentations and talks concerning the use in offices for computer systems and related items.

For more information, contact the Conference Dept, National Micrographics Association, 8719 Colesville Rd, Silver Spring MD 20910.

April 23-25

International DP Training Conference, Hyatt Regency, Chicago IL. The theme for this event will be "The 1980s: The Information Decade." The conference is a symposium for data processing experts and corporate training executives. For information, contact Deltak Inc, 1220 Kensington Rd, Oak Brook IL 60521.■

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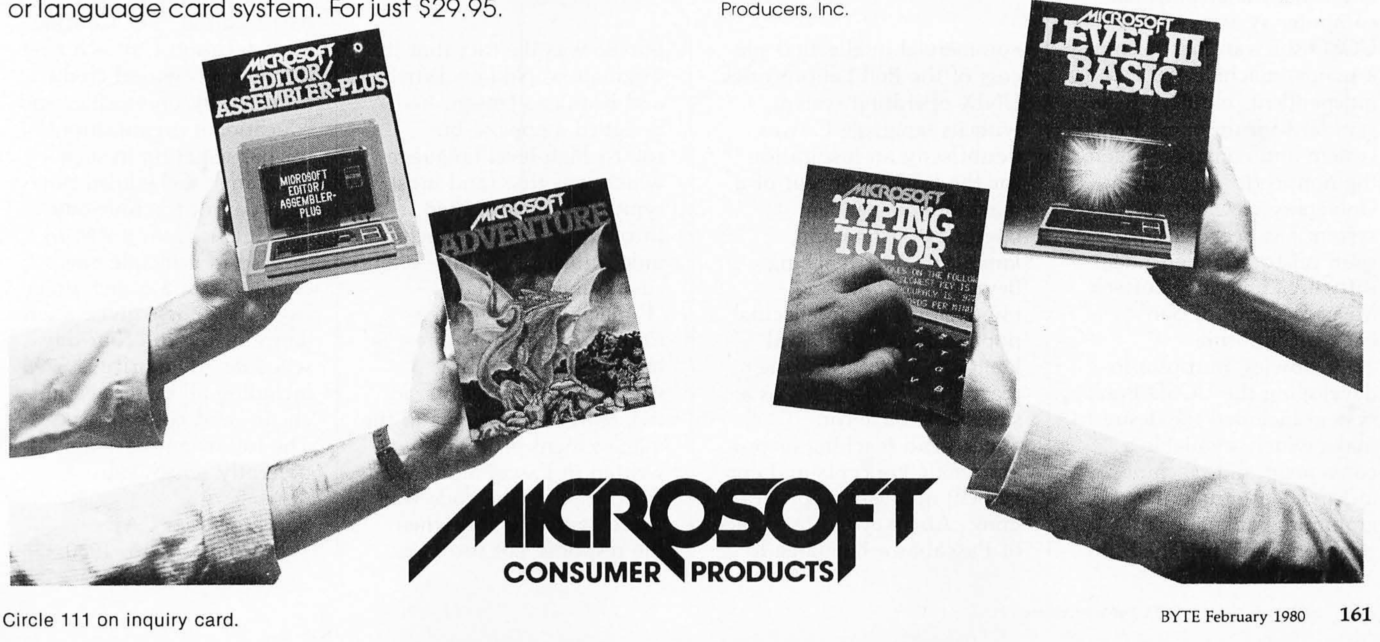
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BYTE's Bits

Ken Bowles' Current Activities: Training in Pascal...

notes by C Helmers

In the last year or so, we have been placing much emphasis on the computer language Pascal, with particular attention to the University of California at San Diego (UCSD) system which, by being available, has become a de facto standard for small-computer, Pascal-oriented systems software. Dr Kenneth Bowles of UCSD was the originator of the project which generated the UCSD system, and he is its prime mover.

As a professor of Computer Science and Electrical Engineering at UCSD, Dr Bowles has been instrumental in the implementation of Pascal on small computers, starting with the LSI-11-based Terak machine, and now including all the major 8-bit microprocessor designs. Since its inception in 1974, UCSD Pascal has been licensed to more than 1000 individuals and organizations. With the recent availability on the Apple II, North Star Horizon, and other major personal computer systems, the UCSD software has become a major, machine-independent, industry-wide standard for an operating system and compiler. Due to the nonprofit status of the University of California, the system has been recently spun off to an independent software company, Softech Micro Systems of San Diego, California.

Dr Bowles' purposes in developing the UCSD Pascal system included the desire to make widely available a convenient and machine-independent structured programming language and operating system. The non-commercial intellectual success of the Bell Laboratories UNIX operating system, with its language C, was doubtlessly an inspiration for the UCSD concept of a machine-independent operating system and language. As a teaching device in schools and universities, the intellectual popularity of the Pascal language was part of the reason for choosing it as a suitable vehicle for widespread teaching of programming concepts and convenient application programming. Also key to the choice of Pascal as a language to pursue was the fact that its originators, Niklaus Wirth and Kathleen Jensen, had designed a concise but robust high-level language which was first (and most typically) implemented through the highly machine-independent technique of simulating a virtual "P-machine" on conventional machines. The rest is history. An operating system with many interactive features, editors and file management programs was written in Pascal along with the compiler; the code was made available and when the response got too large for the university's "non-profit" political environment, the system's marketing and maintenance operations were assigned to a commercial company.

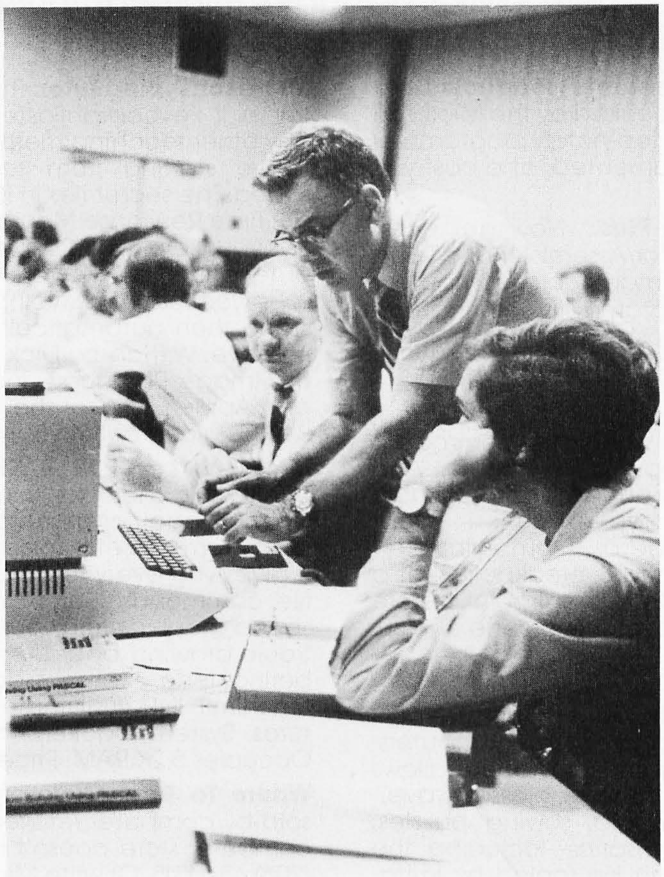


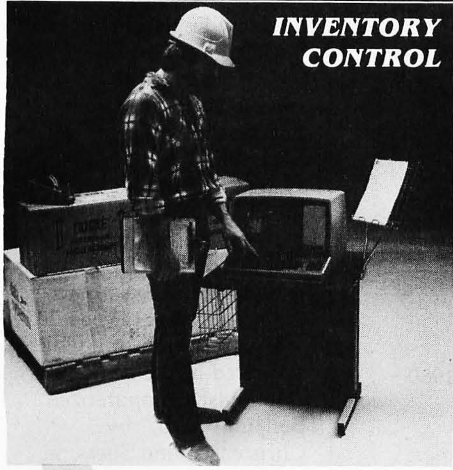
Photo 1: *The hands-on aspect of Ken's Integrated Computer Systems continuing education course on Pascal is provided by use of a number of portable computers such as the Apple II Pascal system. Ken is shown here demonstrating a point to some students.*

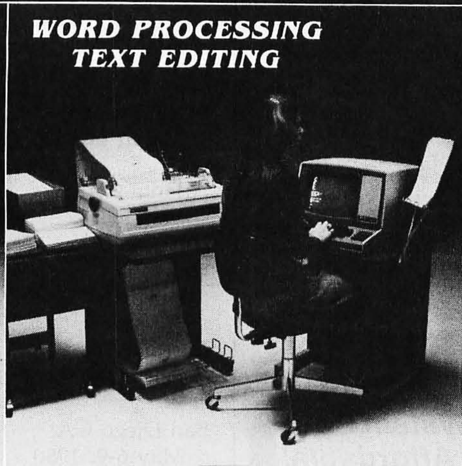
Ken is now participating in the continuing education programs of a company called Integrated Computer Systems Inc. This company specializes in intensive training courses given in major cities, as a sort of traveling road show intended for potential users of high-technology tools such as the Pascal language. Ken's course is designed for engineers, scientists and programmer/analysts who plan to use Pascal for the development of software systems. The class features exercises involving text processing, interactive data collection, dynamic graphic display and real-time control applications. Class sizes are strictly limited to (typically) 36 students in order to provide maximum hands-on activity.

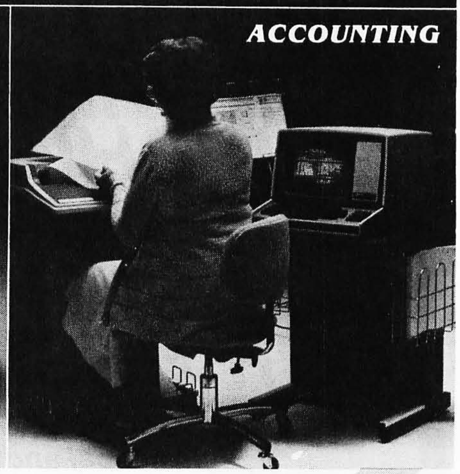
The course is operated for four days (Tuesday thru Friday). Each attendee receives a diploma and one Continuing Education Unit for each 10 hours of participation. The Continuing Education Unit is a nationally recognized credit awarded by universities and educational organizations for participation in such programs. (Scheduled time each day of the four-day schedule is from 9 AM to 6 PM, so in principle one could obtain 3.6 such units from the course given attendance of the full four-day schedule.) The price is $795 including all materials, luncheons and coffee breaks. The following dates are presently scheduled:

San Francisco CA:
February 12-15, 1980

PUTTING IT ALL TOGETHER





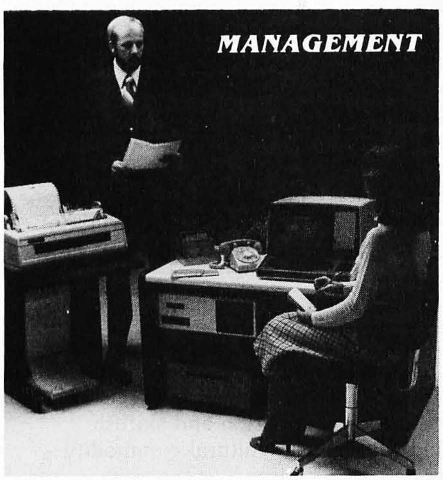


Four-User North Star Horizon *with* 29 Megabyte Hard Disk Interface

INCLUDING:
48K RAM per user
Two 360K 5¼″ disk drives (as many as four, optional)
Two printers:
- One Texas Instruments TI 810 dot matrix, 150 character per second, bi-directional, tractor feed printer with all available options
- One NEC Spinwriter 5510 document quality, full-character printer with friction feed and tractor feed
- Deluxe printer stands and paper trays for both printers

One Discus 29 megabyte (26 megabyte formatted) Winchester technology, fixed hard disk unit with controller, cabinet, power supply, all cables, ports and connectors, completely interfaced to DOS and BASIC, CP/M, PASCAL and Micro Mike's interrupt-driven, bank-switching timesharing (as many as four 29 megabyte hard disk units, seven users, optional)

One custom computer/hard disk desk, Executive model, three CRT stands, thirty 5¼″ diskettes



*Micro Mike's, Incorporated Program Library Membership, including:
- General Ledger
- Accounts Receivable
- Accounts Payable
- Inventory
- CSUB (Common SUBroutines)
- Payroll
- Mail list
- Word Processing/Text Editing
- Project Cattle Profits
- Timesharing
- DOSCHG (eight inch drive interface to DOS and BASIC)
- Commodities Charts
- *and* many outstanding utilities programs and public domain software

*All programs available separately.
Total System $23,719

Micro Mike's, Inc. thoroughly "burns in" and tests all systems delivered as *integrated hardware/software systems,* under timesharing conditions, the ultimate test of a complete computer system. This "burning-in" and testing procedure continues, non-stop, for a minimum of three days and nights, insuring the end user the highest quality, trouble-free integrated hardware/software system possible.

Micro Mike's, Inc. will, for a fee, deliver and set up a system anywhere in the USA. Personal user training and/or custom programming is also available.

Complete North Star Horizon Service Center
Call or write for descriptive literature

★ ★ ★ ★ ★ ★ ★ ★

Discus 29 megabyte Winchester technology fixed, sealed hard disk units completely interfaced to DOS and BASIC, CP/M and PASCAL for most S-100 buss computer systems, ready to go, including controller, cabinet and power supply, all cables, ports and connectors $5,495

Additional 29 megabyte drive, cabinet and power supply $4,495

★ ★ ★ ★ ★ ★ ★ ★

Micro Mike's, Inc. offers a complete selection of top-notch business software. Among comprehensive programs are:

• Time and Expense package for accountants, attorneys, and other professionals • Patient Daily Record Program (Doctor/Patient Ledger) for Physicians • Land Subdivision package • Pharmacy • Motel Reservation with Night Audit • Banker's Trust • Feedlot • Oil/Gas Producer's package • many more

★ ★ ★ ★ ★ ★ ★ ★

IN STOCK:
- North Star Horizons
- Discus double density or quad capacity eight inch drives for S-100 buss systems
- Printers: Texas Instruments TI 810, NEC Spinwriter, IDS-440 Paper Tiger
- Armadillo Armor 5¼″ protective diskette shipping cartons .... $45 per hundred
- Used Intertec Intertube CRTs, as-is condition, close-out $495

MMike's

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905 South Buchanan
Amarillo, Texas 79101 U.S.A.
806-372-3633

making technology uncomplicated . . . for People

Washington DC:
March 4-7, 1980

Los Angeles CA:
March 11-14, 1980

Atlanta GA:
March 18-21, 1980

Houston TX:
April 15-18, 1980

Boston MA:
April 29-May 2, 1980

San Diego CA:
May 6-9, 1980

For further information and enrollment forms, contact Integrated Computer Systems Inc, 3304 Pico Blvd, Santa Monica CA 90405, or phone (213) 450-2060.

Call for Papers—1980 LISP Conference

A call for papers has been announced for the August 24 thru August 27 LISP Conference at Stanford University. The topics should cover languages and theory, programming aspects, architecture, and applications of LISP. Other related items are welcome. Authors are requested to send four copies of a full draft paper not exceeding 4500 words, and a one-page abstract, by March 14, 1980 to the Conference Head. The abstract should provide sufficient detail to allow the committee to apply uniform criteria for acceptance. Authors will be notified of acceptance or rejection by May 16, 1980. For inclusion in the proceedings, final papers are due by June 27, 1980. Send papers to John R Allen, Stanford Artificial Intelligence Lab, Stanford University, Stanford CA 94305, or phone (415) 497-4971 for further details.

Bulletin Board Notes

A computerized bulletin board system (CBBS) is now in operation in Cambridge Massachusetts, thanks to the diligent labors of David Mitton and other members of the New England Computer Society. Running the CBBS code written by Ward Christensen and Randy Suess on a Processor Technology Sol-20, the system is available around the clock. Two data rates are supported, 110 and 300 bits per second (bps). The telephone number to access the system is (617) 864-3819.

A description of a CBBS appeared in the article "Hobbyist Computerized Bulletin Board," by Christensen and Suess, in the November 1978 BYTE, page 150.

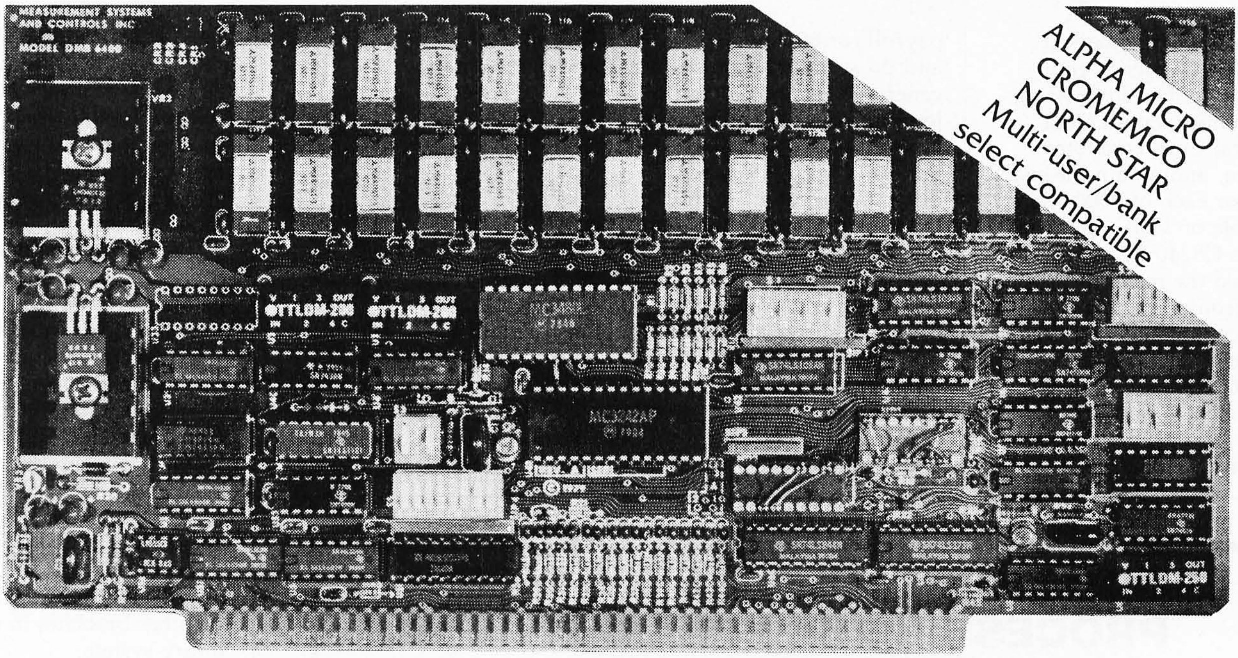
Call a Computer for Computers

If you want to purchase computer equipment, software, terminals, supplies, or any other related equipment, call (813) 885-4811 and talk to a computer. There is no charge but calls are limited to 3 minutes; however, if necessary, you can call again. There should be a listing of the items needed. To access the system: set your terminal for 300 bps operation, set the modem for full duplex originate operation, call (813) 885-4811, after the terminal is on-line enter any character and a carriage return. The system will respond "PLEASE LOG IN", then enter the string "HELLO-Z999," (only the characters underlined), then follow the directions on the terminal to search the file.

To place a listing with the service, contact Basic Online Software Systems Corp, POB 22412, Tampa FL 33622.

Cafeteria Chain Pioneers Computerized Cost Control of Recipes

A chain of cafeterias serving the Los Angeles public has developed a restaurant menu-planning system to minimize the effects of rapid inflation and skittish agricultural commodity prices.



Model DMB-6400 Series dynamic 64k byte RAMS incorporate the features which are standard in the DM-6400 Series and adds bank select for multi-user-timesharing applications.

- ALPHA MICRO, CROMEMCO, and NORTH STAR output port bank select.
- Memory bank size can be incremented to 64k bytes in 16k increments.
- Four (4) 16k byte, functionally independent memory banks.
- Eight (8) 64k byte banks of memory per output port for expansion to 512k bytes for each output port.

Model DM-6400 Series dynamic 64k memory boards feature IEEE S-100 compatible timing and on board transparent refresh.

- Memory selectable and deselectable in 4k byte increments.
- 25 MHz on board crystal oscillator for independent timing.

DMB-6400 and DM-6400 Common Features:

- 4 MHz Z80 operation with no wait states.
- Tested and burned-in.
- Low power- 8 watts maximum.
- Reliable, expandable memories.

ONE YEAR GUARANTEE

THE FOLLOWING PRODUCTS ARE AVAILABLE

☐ DMB-6400/64K RAM ☐ DMB-3200/32K RAM ☐ DM-6400/64K RAM ☐ DM-3200/32K RAM
☐ DMB-4800/48K RAM ☐ DM-4800/48K RAM

ATTRACTIVELY DISCOUNTED OEM AND DEALER QUANTITY PRICES AVAILABLE

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MELBOURNE, VIC3000
TEL: 625581

MEASUREMENT
systems & controls
incorporated

867 North Main Street • Orange, CA 92668
Telephone: 714/633-4460

The menu planners at Clifton's Cafeterias enter current commodity pricing information into a Data General Corp computer system, and obtain the exact cost for each of 2500 recipes possible on Clifton's menus.

The CS/40 system has reduced the menu recost time from 9 months to 6 hours and could save the cafeteria chain about $50,000 annually. In addition to the food purchasing and recipe maintenance, the system can handle the payroll for 600 employees and do accounts payable, a general ledger and a cash journal. The system includes a printer, four video terminals, a magnetic tape drive and a potential 250 K bytes of memory storage on the disk drives.

The CS/40 business system has reduced errors, provided current information, and has allowed for more interesting and more varied menus.

Contact the P R Dept, Data General Corp, Rt 9, Westboro MA 01581, for more information.

Chicago Library Offers Public Computers and a Computerized Reference Service

To permit the public to experience computer-assisted instruction (CAI), to perform basic computer routines and to gain experience in programming, microcomputers have been installed in the Business/-Science/Technology Division of the Central Library, the Popular Library in the Cultural Center, the Woodson Regional Library, and the Lincoln Park Branch, all agencies of the Chicago Public Library.

The system includes video displays, software, training manuals, but no printers. It runs on BASIC, and has 8 K bytes of programmable memory. Engineers, businessmen, students developing chess skills, and people balancing their checkbooks have been using the devices. If usage increases substantially, the Library will consider the purchase of additional units for other branches in the library system.

Their other service provides millions of references to books, periodicals, reports, all on a wide range of subjects. Where manual research can take hours or even days, the computerized service can reduce to only a few minutes the time usually required for a thorough research study. For this service, the first 5 minutes of computer time are free and each additional minute costs $1.50. Contact the Business/Science/Technology Division in the Central Library at 425 N Michigan Ave, Chicago IL 60611, or call (312) 269-2915.

Apple Education Foundation Advances Learning Methods Through Microcomputers

Initially funded by Apple Computer, the nonprofit foundation will offer support and resources to organizations and individuals who are pioneering learning methods through the use of microcomputers. Funding authorizations through 1980 are valued in excess of $250,000. The foundation will distribute hardware equipment for both developmental and demonstration projects involved in producing instructional computing materials. The foundation's primary

TIME after TIME



BATTERY SUPPORTED CALENDAR CLOCKS

PDP-11*

TCU-100 • $495

- Provides month, day, hour, minute and second.
- Can interrupt on date/time, or periodic intervals.

TCU-150 • $460

- Provides year, month, day, hour, minute and second.
- Automatic leap year.
- Patches for RSX-11M, RT-11 FB/SJ VO2, VO3 and UNIX.

LSI-11/2*

TCU-50D • $325

- Provides month, day, hour, minute and second.
- Dual size board.
- Patches for RT-11 SJ/FB VO2, VO3B.

Lockheed SUE

TCU-200 • $550

- Provides year, month, day, hour, minute, second and milli-second.
- Interval interrupts between 1/1024 seconds and 64 seconds.

Computer Automation (Naked Mini)

TCU-310 • $385

- Provides year, month, day, hour, minute and second.

Multi-Bus**

TCU-410 • $325

- Provides year, month, day, hour, minute and second.
- SBC/BLC compatible.

HP 2100

TCU-2100 • $395

- Correct time restored after power failure.
- Compatible with the HP TBG card.

Serial Clock (RS 232 or 20 mA)

SLC-1 • $640

- Connects between any terminal and host computer.
- Provides date, time and more!

All Digital Pathways TCUs have on board NICAD batteries to maintain time and date during power down. Timing is provided by a crystal controlled oscillator. Prices are U.S. domestic single piece. Quantity discounts available.

For more information on these products, contact:
Digital Pathways Inc.
4151 Middlefield Road
Palo Alto, CA 94306
Phone: (415) 493-5544

**Trademark of Digital Equipment Corporation*

***Trademark of Intel Corporation*

****Trademark of Computer Automation Incorporated*

DIGITAL PATHWAYS

Circle 117 on inquiry card.





goal is to place hardware into the hands of people who will further those educational methods that best take advantage of the personal microcomputer's capabilities.

As continuing evidence of its commitment to education, the foundation will sponsor the Education Program Information Center (EPIC). EPIC will support microcomputer users in developing new instructional programs and in obtaining available information on educational materials. Authors are encouraged to submit their work to the center for review and feedback on the most effective uses and placements of their materials.

Both the Apple Education Foundation and EPIC may be contacted through the Apple Education Foundation, 20605 Lazaneo Dr, Cupertino CA 95014.

AIDs for Apple Dealers

AIDs (Apple Independent Dealers) was formed by and for independent Apple dealers, ie: those dealers with no direct contractual agreement or connection with any national chain or franchise. AIDs will provide a framework for improved communication, education, and support to its members, which will also be of benefit to consumers. This will include sharing of information on new software and hardware evaluations, successful marketing and problem solving, advertising ideas and more.

Full membership for qualified dealers is $35 per year. For more information, contact Harry Sweeney, (503) 228-5242 or send a self-addressed, stamped envelope to AIDs, POB 06126, Portland OR 97206.

Report Studies Threat to Auto Electronics from Electric Fields

With the increased use of electronic control systems in automobiles, there is concern about possible malfunction or deterioration of function due to ambient electrical fields created by radio and television transmitters, high-powered radar, power transmission lines, or lightning strokes.

Researchers at the National Telecommunications and Information Administration (NTIA) have surveyed sources emanating energy across the radio-frequency portion of the electromagnetic spectrum. Their report indicates that vehicles might sometimes — although rarely — be exposed to radio-frequency fields of 5 kV per meter which may cause the vehicle to become inoperative or may even damage its electronics.

The report is available from the National Technical Information Service, 5285 Port Royal Rd, Springfield VA 22161 for $4.50. The accession number is PB 294-819/AS. For further information, contact NTIA Office of Congressional and Public Affairs (202) 377-1832. ■

BYTE's Bugs

Correct Reversi Termination

I would like to point out a programming error in "Reversi," which was published in the November 1979 BYTE, on page 76. The problem with the program is that it recognizes the end-of-game criterion too early, allowing the occurrence of a player not having a move only twice throughout the length of the game. This is due to the fact that counter-variable T3 is never re-initialized when a player is able to move. I recommend insertion of the following code: 296 LET T3=0.

Darrell Pittman
4225 Forest Dr
Port Arthur TX 77640 ■

By Netronics

ASCII/BAUDOT, STAND ALONE



Computer Terminal

COMPLETE FOR ONLY . . . $149^95

The Netronics ASCII/BAUDOT Computer Terminal Kit is a microprocessor-controlled, stand alone keyboard/terminal requring no computer memory or software. It allows the use of either a 64 or 32 character by 16 line professional display format with selectable baud rate, RS232-C or 20 ma. output, full cursor control and 75 ohm composite video output.

The keyboard follows the standard typewriter configuration and generates the entire 128 character ASCII upper/lower case set with 96 printable characters. Features include onboard regulators, selectable parity, shift lock key, alpha lock jumper, a drive capability of one TTY load, and the ability to mate directly with almost any computer, including the new Explorer/85 and ELF products by Netronics.

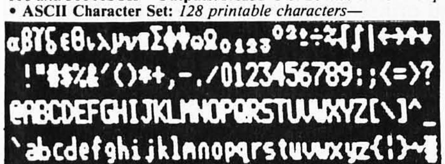
The Computer Terminal requires no I/O mapping and includes 1k of memory, character generator, 2 key rollover, processor controlled cursor control, parallel ASCII/BAUDOT to serial conversion and serial to video processing—fully crystal controlled for superb accuracy. PC boards are the highest quality glass epoxy for the ultimate in reliability and long life.

VIDEO DISPLAY SPECIFICATIONS

The heart of the Netronics Computer Terminal is the microprocessor-controlled Netronics Video Display Board (VID) which allows the terminal to utilize either a parallel ASCII or BAUDOT signal source. The VID converts the parallel data to serial data which is then formatted to either RS232-C or 20 ma. current loop output, which can be connected to the serial I/O on your computer or other interface, i.e., Modem.

When connected to a computer, the computer must echo the character received. This data is received by the VID which processes the information, converting to data to video suitable to be displayed on a TV set (using an RF modulator) or on a video monitor. The VID generates the cursor, horizontal and vertical sync pulses and performs the housekeeping relative to which character and where it is to be displayed on the screen.

Video Output: *1.5 P/P into 75 ohm (EIA RS-170)* • **Baud Rate:** *110 and 300 ASCII* • **Outputs:** *RS232-C or 20 ma. current loop* • **ASCII Character Set:** *128 printable characters*—



BAUDOT Character Set: *A B C D E F G H I J K L M N O P Q R S T U V W X Y Z - ? : * 3 $ # ( ) . , 9 0 1 4 ! 5 7 ; 2 / 6 8 •* **Cursor Modes:** *Home, Backspace, Horizontal Tab, Line Feed, Vertical Tab, Carriage Return. Two special cursor sequences are provided for absolute and relative X-Y cursor addressing* • **Cursor Control:** *Erase, End of Line, Erase of Screen, Form Feed, Delete* • **Monitor Operation:** *50 or 60Hz (jumper selectable.*

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To Order From Connecticut Or For Technical Assistance, Etc. **Call (203) 354-9375**

Netronics R&D Ltd., Dept. PE-9
333 Litchfield Road, New Milford, CT 06776

Please send the items checked below—

☐ **Netronics Stand Alone ASCII Keyboard/Computer Terminal Kit, $149.95** plus $3.00 postage & handling.
☐ **Deluxe Steel Cabinet** for Netronics Keyboard/Terminal In Blue/Black Finish, **$19.95** plus $2.50 postage and handling.
☐ **Video Display Board Kit** alone (less keyboard), **$89.95** plus $3 postage & handling.
☐ **12" Video Monitor** (10 MHz bandwidth) fully assembled and tested, **$139.95** plus $5 postage and handling.
☐ **RF Modulator Kit** (to use your TV set for a monitor), **$8.95** postpaid.
☐ **5 amp Power Supply Kit** In Deluxe Steel Cabinet (±8VDC @ 5 amps, plus 6-8 VAC), **$39.95** plus $2 postage & handling.

Total Enclosed (Conn. res. add sales tax) $________ By—
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Start Computing For Just $129.95 With An 8085-Based Professional Computer Kit—

Explorer/85

100% compatible with all 8080A and 8085 software & development tools!

No matter what your future computing plans may be, Level "A"—at $129.95—is your starting point.

Starting at just $129.95 for a Level "A" operating system, you can now build the exact computer you want. Explorer/85 can be your beginner's system, OEM controller, or IBM-formatted 8" disk small business system... yet you're never forced to spend a penny for a component or feature you don't want and you can expand in small, affordable steps!

Now, for just $129.95, you can own the first level of a fully expandable computer with professional capabilities—a computer which features the advanced Intel 8085 cpu, *thereby giving you immediate access to all software and development tools that exist for both the 8085 and its 8080A predecessor (they are 100% software compatible)*—a computer which features onboard S-100 bus expansion—plus instant conversion to mass storage disk memory with either 5-1/4" diskettes or standard IBM-formatted 8" disks.

For just $129.95 (plus the cost of a power supply, keyboard/terminal and RF modulator, if you don't have them already), Explorer/85 lets you begin *computing* on a significant level... *applying* the principles discussed in leading computer magazines... *developing* "state of the art" computer solutions for both the industrial and leisure environment.

Level "A" Specifications

Explorer/85's Level "A" system features the advanced Intel 8085 cpu, an 8355 ROM with 2k deluxe monitor/operating system, and an 8155 ROM-I/O—all on a single motherboard with room for RAM/ROM/PROM/EPROM and S-100 expansion, *plus* generous prototyping space.

(Level "A" makes a perfect OEM controller for industrial applications and is available in a special Hex Version which can be programmed using the Netronics Hex Keypad/Display.)



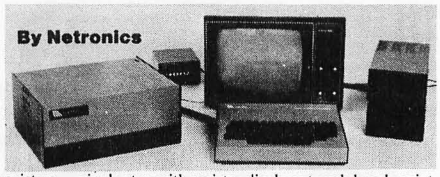
Level "A" at $129.95 is a complete operating system, perfect for beginners, hobbiests, or industrial controller use.

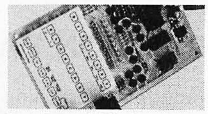
PC Board: glass epoxy, plated through holes with solder mask • **I/O:** provisions for 25-pin (DB25) connector for terminal serial I/O, which can also support a paper tape reader ...provision for 24-pin DIP socket for hex keyboard/display... cassette tape recorder input... cassette tape recorder output... cassette tape control output... speaker output... LED output indicator on SOD (serial output) line... printer interface (less drivers)... total of four 8-bit plus one 6-bit I/O ports • **Crystal Frequency:** 6.144 MHz • **Control Switches:** reset and user (RST 7.5) interrupt... additional provisions for RST 5.5, 6.5 and TRAP interrupts onboard • **Counter/Timer:** programmable, 14-bit binary • **System RAM:** 256 bytes located at F800, ideal for smaller systems and for use as an isolated stack area in expanded systems... RAM expandable to 64k via S-100 bus or 4K on motherboard.

System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at F000 leaving 0000 free for user RAM/ROM. Features include tape load with labeling ... tape dump with labeling... examine/change contents of memory ... insert data... warm start... examine and change all registers... single step with register display at each break point, a debugging/training feature... go to execution address... move blocks of memory from one location to another... fill blocks of memory with a constant... display blocks of memory ... automatic baud rate selection... variable display line length control (1-255 characters/line)... channelized I/O monitor routine with 8-bit parallel output for high speed printer... serial console in and console out channel so that monitor can communicate with I/O ports.

System Monitor (Hex Version): Tape load with labeling... tape dump with labeling... examine/change contents of memory... insert data... warm start... examine and change all registers... single step with register display at each break point ... go to execution address. Level "A" in the *Hex Version* makes a perfect controller for industrial applications and can be programmed using the Netronics Hex Keypad/Display.

By Netronics





Hex Keypad/Display.

Hex Keypad/Display Specifications

Calculator type keypad with 24 system defined and 16 user defined keys. 6 digit calculator type display which displays full address plus data as well as register and status information.

Level "B" Specifications

Level "B" provides the S-100 signals plus buffers/drivers to support up to six S-100 bus boards and includes: address decoding for onboard 4k RAM expansion select-able in 4k blocks... address decoding for onboard 8k EPROM expansion selectable in 8k blocks... address and data bus drivers for onboard expansion... wait state generator (jumper selectable), to allow the use of slower memories... two separate 5 volt regulators.



Explorer/85 with Level "C" card cage.

Level "C" Specifications

Level "C" expands Explorer's motherboard with a card cage, allowing you to plug up to six S-100 cards directly into the motherboard. Both cage and cards are neatly contained inside Explorer's deluxe steel cabinet. Level "C" includes a sheet metal superstructure, a 5-card gold plated S-100 extension PC board which plugs into the motherboard. Just add required number of S-100 connectors

Level "D" Specifications

Level "D" provides 4k or RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original 256 bytes located in the 8155A). The static RAM can be located anywhere from 0000 to EFFF in 4k blocks.

Level "E" Specifications

Level "E" adds sockets for 8k of EPROM to use the popular Intel 2716 or the TI 2516. It includes all sockets, power supply regulator, heat sink, filtering and decoupling components. Sockets may also be used for soon to be available RAM IC's (allowing for up to 12k of onboard RAM).

Order A Coordinated Explorer/85 Applications Pak!

Experimenter's Pak (SAVE $12.50)—Buy Level "A" and Hex Keypad/Display for **$199.90** and get FREE Intel 8085 user's manual plus FREE postage & handling!

Student Pak (SAVE $24.45)—Buy Level "A," ASCII Keyboard/Computer Terminal, and Power Supply for **$319.85** and get FREE RF Modulator plus FREE Intel 8085 user's manual plus FREE postage & handling!

Engineering Pak (SAVE $41.00)—Buy Levels "A," "B," "C," "D," and "E" with Power Supply, ASCII Keyboard/Computer Terminal, and six S-100 Bus Connectors for **$514.75** and get 10 FREE computer grade cassette tapes plus FREE 8085 user's manual plus FREE postage & handling!

Business Pak (SAVE $89.95)—Buy Explorer/85 Levels "A," "B," and "C" (with cabinet), Power Supply, ASCII Keyboard/Computer Terminal (with cabinet), 16k RAM, 12" Video Monitor, North Star 5-1/4" Disk Drive (includes North Star BASIC) with power supply and cabinet, all for just **$1599.40** and get 10 FREE 5-1/4" minidiskettes ($49.95 value) plus FREE 8085 user's manual plus FREE postage & handling!

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Netronics R&D Ltd., Dept. RE 10
333 Litchfield Road, New Milford, CT 06676

Please send the items checked below—

☐ **Explorer/85 Level "A" Kit** (ASCII Version), **$129.95** plus $3 p&h.
☐ **Explorer/85 Level "A" Kit** (Hex Version), **$129.95** plus $3 p&h.
☐ **8k Microsoft BASIC** on cassette tape, **$64.95** postpaid.
☐ **8k Microsoft BASIC in ROM Kit** (requires Levels "B," "D," and "E"), **$99.95** plus $2 p&h.
☐ **Level "B" (S-100) Kit, $49.95** plus $2 p&h.
☐ **Level "C" (S-100 6-card expander) Kit, $39.95** plus $2 p&h.
☐ **Level "D" (4k RAM) Kit, $69.95** plus $2 p&h.
☐ **Level "E" (EPROM/ROM) Kit, $5.95** plus 50¢ p&h.
☐ **Deluxe Steel Cabinet** for Explorer/85, **$49.95** plus $3 p&h.
☐ **ASCII Keyboard/Computer Terminal Kit** (features a full 128 character set, upper & lower case, full cursor control, 75 ohm video output convertible to baudot output, selectable baud rate, RS232-C or 20 ma. I/O, 32 or 64 character by 16 line formats, and can be used with either a CRT monitor or a TV set (if you have an RF modulator), **$149.95** plus $2.50 p&h.
☐ **Hex Keypad/Display Kit, $69.95** plus $2 p&h.
☐ **Deluxe Steel Cabinet** for ASCII Keyboard/Terminal, **$19.95** plus $2.50 p&h.
☐ **Power Supply Kit** (±8V @ 5 amps) in deluxe steel cabinet, **$39.95** plus $2 p&h.
☐ **Gold Plated S-100 Bus Connectors, $4.85** each, postpaid.
☐ **RF Modulator Kit** (allows you to use your TV set as a monitor), **$8.95** postpaid.
☐ **16k RAM Kit** (S-100 Board expands to 64k), **$199.95** plus $2 p&h.
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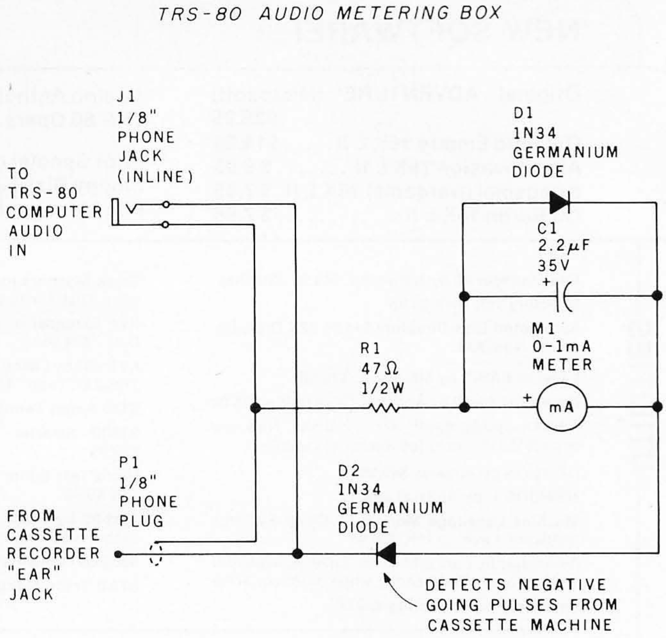
Audio Meter for Your TRS-80

David F Miller, 7462 Lawler Ave, Niles IL 60648

Perhaps I am old-fashioned, but I like to know what is happening when I CLOAD or CSAVE a tape on my TRS-80. I modified the CTR-41 cassette recorder to allow me to hear over its internal speaker what is going in and coming out at all times, but that did not tell me enough about the levels involved.

As you have probably discovered, audio levels in and out of the cassette port are very important for the successful loading and saving of your hard-fought-for efforts on tape. Interpolating the volume control settings of the cassette unit on playback can produce a degree of accuracy, but not for tapes received from others. The only sure way to understand what is going on is a visual indicator. The best device would be an oscilloscope, but I could not see dedicating my oscilloscope permanently to this type of duty.

The metering circuit shown in figure 1 has proven to be adequate for day-to-day monitoring and can be supplemented by the oscilloscope when a difficult tape is encountered. If you have an oscilloscope, look at the earphone output of the cassette recorder while playing back a tape. What you will see is a constant synchronization train of negative pulses occurring at a frequency of 500 Hz, with negative data pulses popping in and out at 1000 Hz. (These figures are for Level II. Level I figures are half, or 250 Hz and 500 Hz.)



	RADIO SHACK NUMBER
C1	272-1407
D1 & D2	276-1123
J1 & P1	274-283
M1	22-052 OR EQUIVALENT
R1	271-009

Figure 1: *Schematic for the TRS-80 audio metering box. The 2 diodes used must be germanium diodes.*

The metering circuit shown in figure 1 samples these negative pulses, rectifies and filters them, and drives the 1 mA meter movement. With the values shown, the meter will read about half scale with the volume on the cassette unit set at 5 (normal setting for Level II tapes). To trim the meter reading for your individual needs, change the value of the electrolytic capacitor across the meter (more capacity for a higher reading); this will probably have the most noticeable effect. You could also increase or decrease the 47 ohm series resistor, but watch for possible "loading" effects if you go too low in value (the value shown shows no such effects). The diode across the meter acts to protect the movement when high levels are encountered (such as during a tape search in fast forward or rewind with the "play" button also engaged). Both diodes are specified as germanium because there is only 0.3 V barrier potential (ie, voltage drop) across a germanium type, whereas a silicon diode has 0.7 V drop.

The earphone jack on the CTR-41, and most other recorders, outputs the audio signal from the record amplifier when in the record mode, so you will see what is CLOADed *and* what is CSAVEed.

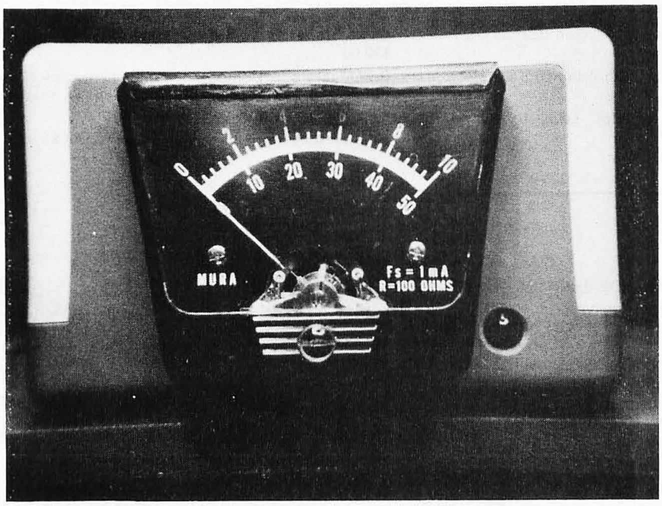


Photo 1: *A view of the audio metering box which connects to the Radio Shack TRS-80.*

Photo 1 shows how my unit is packaged. I mounted a 1/8 inch phone jack on the rear of the plastic meter box which accepts the plug to the TRS-80. This jack should be insulated from the box if you use a metal enclosure, or

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24K Econoram VIIA-24	S-100	$419	$499	$605
16K Econoram IX-16	Dig Grp	$319	$379	n/a
32K Econoram IX-32	Dig Grp	$559	$639	n/a
32K Econoram X	S-100	$549	$669	$789
32K Econoram XI	SBC/BLC	n/a	n/a	$1050
16K Econoram XIIIA-16	S-100 (1)	$349	$419	$519
24K Econoram XIIIA-24	S-100 (1)	$469	$539	$649
32K Econoram XIIIA-32	S-100 (1)	$579	$699	$849
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use an in-line female 1/8 inch phone jack and avoid having to keep the jack above possible outside grounds. A short shielded cable exits the meter box, terminates in an 1/8 inch phone plug, and plugs into the recorder ear jack.

That is all there is to it! If your cassettes are marked with the meter readings that are obtained on playback, you should be able to load almost anything on the first pass. If you see the level on playback begin to drop over a period of time, you will know that the tape heads need cleaning. I think you will find that this is a useful accessory. ■

Algebraic Identities Are Not Numerical Identities

Alan B Forsythe PhD, University of California Los Angeles
Department of Biomathematics, School of Medicine
Los Angeles CA 90024

The development of statistical software can present some adverse computational problems. In "Elements of Statistical Computation" (January 1979 BYTE, page 182), I demonstrated the tip of this iceberg with two algorithms for calculating the standard deviation for some data. The first algorithm, the one given in many texts, incorrectly gives zero as the answer. The simple modification given in that article corrects the defect. This clearly shows the fallacy of simply coding the computational procedures given in standard textbooks.

Subsequently, J G Bliss erroneously speculated that a division by four rather than five (N-1 rather than N) probably accounts for the incorrect answer. (See "Statistical Computations Recomputed," June 1979 BYTE, page 193.) As my original article pointed out, the root of the problem is the fact that digital computers have finite precision. Algebraic identities are *not* numerical identities. Thus, when very large numbers are added or subtracted, the last few digits are lost due to truncation. When faced with deviations from large numbers, the user has to be very careful with the computational formula employed. That is why a better answer can be obtained using the last algorithm given in the article.

A simple example on the TRS-80 is:

```
PRINT 1000000+1
```

The resulting display shows 1E6. That is, one million plus one is reported to equal one million. The single-precision representation is not adequate for this problem.

The heart of the computation of the standard deviation is the sum of the squares of the deviations about the mean. Algebraically this can be deduced from the sum of the squares of the individual values and their sum. The original article demonstrates that the use of this algebraic identity leads to the subtraction of two very large numbers and thereby to the loss of the critical digits. The computed result for the sum of squares of the deviations is zero. It is now clear that if a computationally poor procedure yields zero, then it certainly does not matter if we divide by five or four. In either case, we still get zero.

Why is there any question whether to divide by N or N−1 in the calculation of the standard deviation? When given the values for the entire population, then divide by N; when working with a *sample*, then divide by N — 1. The example in the original article was a sample from a much larger population and so the correct divisor of N−1 was used.

Mr Bliss references an accounting and auditing textbook. If, in the auditing situation, in order to verify each and every of the thousands of bills paid, then the divisor should be N. However, if only a sample was drawn, then N−1 is the appropriate divisor for the standard deviation.

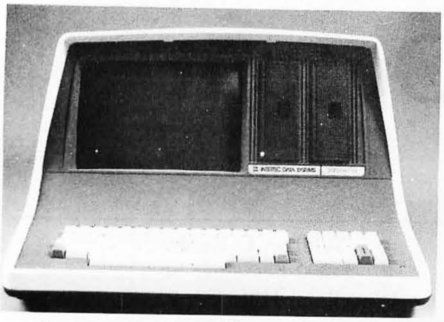
Since I am a statistician and not an accountant, I will not argue with Mr Bliss about accounting. If his usual procedure is to exhaustively study all transactions, rather than a sample, then he should divide by N. My experience with sampling from large populations has been that great economy of effort can be realized without much loss in precision with the use of an appropriate sampling plan. ■

REFERENCES

1. Bliss, J F, "Statistical Computations Recomputed," BYTE, June 1979, page 193.
2. Forsythe, A B, "Elements of Statistical Computation," BYTE, January 1979, page 182.

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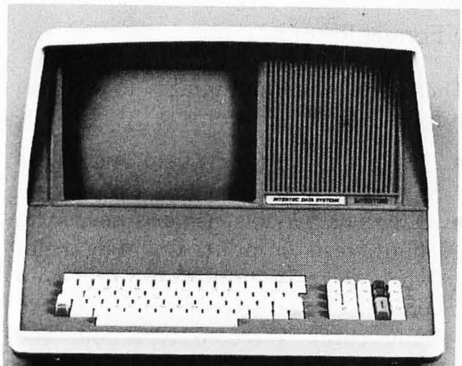
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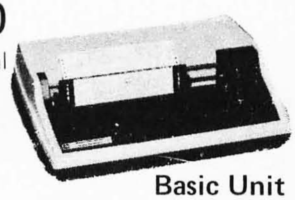
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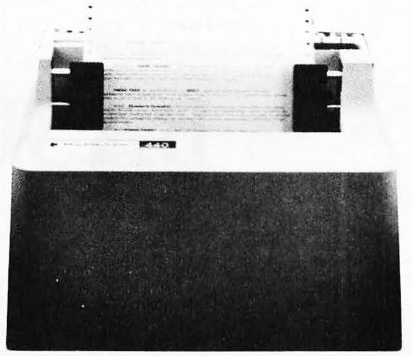
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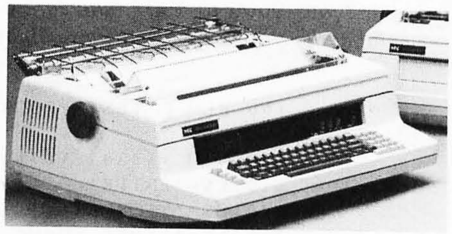
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Format Definition Routine

Our primary concern is describing the appearance of the record format to the rou-

Text continued on page 185

Listing 1: BASIC source code for the editing routines. Lines 100 to 927 are the driver program for the text editor. Lines 9000 to 9997 are the actual text editor. The editor is located at a high line number so it may be used with many BASIC programs. When using the editor, care must be taken not to use any line numbers in your driver program higher than 9000. The editor is broken into several routines. Lines 9000 through 9185 define the format that will be used. The format statement will be familiar to readers who have worked with FORTRAN format statements. Lines 9200 to 9268 parse the format statement. The parsed format is stored in arrays V$ and V as described in the text.

Lines 9300 to 9548 are the free format input routine. The data is entered with commas separating the individual units. This routine then takes the data and puts it into the desired form.

Lines 9600 to 9997 take care of formatted output. The format used is a table developed by a routine such as that in lines 9200 to 9268.

```
100 REM   TEST PROGRAM FOR FORMAT SUBROUTINES
110 REM
200 DIM V$(30),V(30),Y(3,30)
210 E$="ENTER"
220 G$=" FORMAT"
230 H$=" FREE FORM"
240 I$=" FORMATTED"
250 J$=" STRINGS IN QUOTES"
260 K$=" & VARIABLES"
300 INPUT "INSTRUCTIONS (Y OR N):";Y$
310 IF Y$="N" GOTO 370
320 PRINT: PRINT "USE CODE FOR FOLLOWING TESTS"
330 PRINT "1 =";G$;" & TABLE"
340 PRINT "2 =";G$;",";H$;K$
350 PRINT "3 =";G$;",";I$;" STRING";K$
360 PRINT "4 = INPUT";G$;",";H$;" OUTPUT";G$
370 INPUT "ENTER CODE:";A$
375 PRINT
380 IF A$="?" GOTO 320
384 IF A$="END" OR A$="E" THEN STOP
386 A=VAL(A$)
390 ON A GOTO 400,500,700,800
400 PRINT E$;G$
410 INPUT F$
420 GOSUB 9060
425 PRINT: PRINT
430 FOR K=1 TO Y9-1
440 PRINT Y(1,K);Y(2,K);Y(3,K)
450 NEXT K
460 PRINT
470 GOTO 370
500 PRINT E$;G$
510 INPUT F$
520 PRINT E$;H$;J$
530 INPUT Z$
540 GOSUB 9060
550 GOSUB 9400
```

Listing 1 continued on page 178

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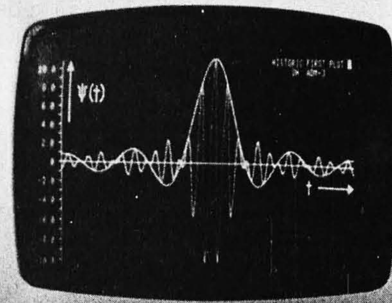
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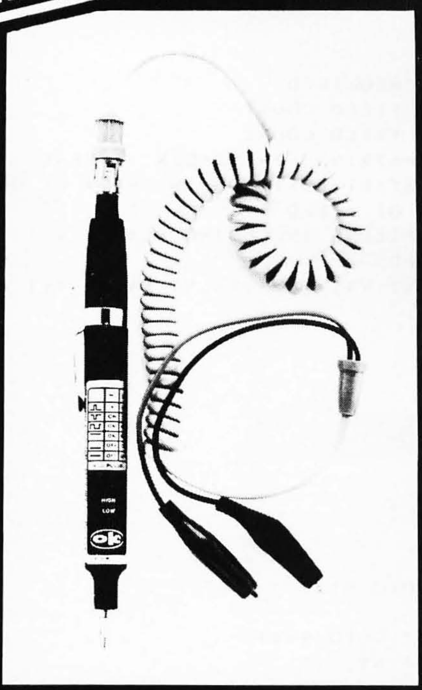
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Circle 127 on inquiry card.

Listing 1 continued:

```
560 PRINT: PRINT "STRINGS"
570 FOR K=1 TO V1
580 PRINT V$(K)
590 NEXT
600 PRINT: PRINT "NUMBERS"
610 FOR K=1 TO V2
620 PRINT V(K)
630 NEXT
640 PRINT
650 GOTO 370
700 PRINT E$;G$
710 INPUT F$
720 GOSUB 9060
730 PRINT: PRINT E$;I$;J$
740 INPUT Z$
750 GOSUB 9260
760 GOTO 560
800 PRINT E$;G$
810 INPUT F$
820 GOSUB 9060
830 PRINT E$;H$;J$
840 INPUT Z$
850 PRINT E$;" OUTPUT";G$
860 INPUT F$
870 GOSUB 9060
875 GOSUB 9400
880 GOSUB 9650
890 PRINT: PRINT U$: PRINT
900 GOTO 370
927 REM
8998 REM
8999 REM
9000 REM    FORMAT DEFINITION SUBROUTINE [SUB I/O IA.0]
9003 REM
9006 REM THIS ROUTINE BREAKS UP A 'FORTRAN' TYPE FORMAT
9009 REM STATEMENT INTO A TABLE FOR USE WITH [SUB IB,IC,ID]
9010 REM EXAMPLE:
9012 REM    F$="(A3,4X,2F7.2,X,3I6)"
9015 REM    A3      - 3 CHAR STRING (3A - BAD ENTRY)
9018 REM    4X      - 4 BLANKS (4X6 - 6 IGNORED)
9021 REM    2F7.2   - 2 REAL NOS OF 7 CHARS W/ 2 DECIMAL PLACES
9024 REM    X       - 1 BLANK
9027 REM    3I6     - 3 INTEGERS 6 CHAR LONG
9030 REM
9033 REM INPUT:
9036 REM    F$ - FORMAT
9039 REM OUTPUT:      DIM AS REQUIRED
9040 REM    V1      - STRING FIELD COUNT
9041 REM    V2      - NUMBER FIELD COUNT
9042 REM    Y(1,K) - TYPE 1=STRING, 2=INTEGER, 3=REAL, 4=BLANK
9045 REM    Y(2,K) - FIELD START POSITION IN INPUT OR OUTPUT RECORD
9048 REM    Y(3,K) - LENGTH OF FIELD
9051 REM    Y9      - NO OF FIELDS INCLUDING BLANKS + 1
9054 REM VARIABLE NAMES USED:
9057 REM    F$,U$,W$,X$,V1,V2,V3,V4,V5,V6,V7,V8,V9,Y(I,K),Y9
9058 REM
9060 V1=1
9069 V2=1
9072 V5=1
9075 Y9=1
9081 Y(2,1)=1
9084 W$=""
9087 U$="AIFX ,)."
9090 FOR V7=2 TO LEN(F$)
9093 X$=MID$(F$,V7,1)
9096 FOR V8=1 TO 8
9099 IF X$=MID$(U$,V8,1) GOTO 9112
9100 NEXT V8
9103 IF X$>="0" AND X$<="9" GOTO 9142
9106 PRINT "FORMAT ERROR (";X$;")"
9109 STOP
9112 IF V8<5 GOTO 9121
9115 V8=V8-4
```

Listing 1 continued on page 180

Listing 1 continued:

```
9118 GOTO 9139
9121 V9=V8
9130 V6=V6+1
9133 IF V6=2 THEN V5=VAL(W$)
9136 GOTO 9181
9139 IF V8<>4 GOTO 9151
9142 W$=W$+X$
9145 V6=1
9148 GOTO 9184
9151 V4=VAL(W$)
9153 IF V5=0 THEN V5=1
9154 IF V9=4 THEN V4=V5
9157 IF V9=4 THEN V5=1
9160 FOR V3=1 TO V5
9161 Y(1,Y9)=V9
9163 Y(3,Y9)=V4
9166 Y(2,Y9+1)=INT(Y(2,Y9)+V4)
9169 Y9=Y9+1
9170 IF V9=2 OR V9=3 THEN V2=V2+1
9171 IF V9=1 THEN V1=V1+1
9172 NEXT V3
9175 V5=1
9178 V6=1
9181 W$=""
9184 NEXT V7
9185 RETURN
9190 REM
9192 REM
9200 REM    BREAKS UP A FORMATTED STRING SUBROUTINE [SUB I/O 1B.0]
9203 REM
9206 REM THIS SUBROUTINE BREAKS UP A FORMATTED STRING RECORD FROM:
9209 REM    1. READ FROM INPUT STATEMENT
9212 REM    2. READ FROM DATA STATEMENT
9215 REM    3. FORMATTED INPUT - STRING MUST BE IN QUOTES (")
9218 REM    4. INPUT STATEMENT USING BASIC PATCHED FOR USE
9219 REM       WITH RO-CHE MULTI-CASSETTE CONTROLLER
9221 REM INTO STRING AND NUMBER ARRAYS BASED ON A TABLE BUILT
9224 REM INTP THE PROGRAM OR FROM PARAMETERS CREATED BY [I/O 1A.0]
9227 REM
9230 REM INPUT:
9233 REM    Z$      - INPUT STRING
9236 REM    Y(K,I)- PARAMETER TABLE
9239 REM    Y9      - NO OF FIELDS INCLUDING BLANK FIELDS
9242 REM OUTPUT:
9245 REM    V$(I)  - STRING FIELD ARRAY
9248 REM    V(I)   - NUMBER FIELD ARRAY
9251 REM VARIABLE NAMES USED:
9254 REM    V$(I),Z$,V(I),V1,V2,V7,Y(I,K),Y9
9260 V1=0
9266 V2=0
9269 FOR V7=1 TO Y9-1
9272 ON Y(1,V7) GOTO 9275,9284,9284,9290
9275 V1=V1+1
9278 V$(V1)=MID$(Z$,Y(2,V7),INT(Y(3,V7)))
9281 GOTO 9290
9284 V2=V2+1
9287 V(V2)=VAL(MID$(Z$,Y(2,V7),INT(Y(3,V7))))
9290 NEXT V7
9293 Z$=""
9296 RETURN
9297 REM
9298 REM
9300 REM    FREE FORM INPUT SUBROUTINE [SUB I/O 1C.0]
9303 REM
9306 REM THIS ROUTINE ACCEPTS A FREE FORM INPUT STRING AND PRO-
9309 REM DUCES A STRING AND/OR NUMBER ARRAY BASED ON A TABLE BUILT
9312 REM INTO THE PROGRAM OR CREATED BY [SUB I/O 1A].
9315 REM BLANKS ARE USED AS DELIMITERS BETWEEN FIELDS.
9316 REM STRING FIELDS CONTAINING BLANKS OR WITH
9318 REM LEADING OR TRAILING BLANKS MUST BE
9321 REM ENCLOSED WITH A DELIMITER.  NUMERIC FIELDS ARE
9324 REM EDITED FOR NON-NUMERIC CHARACTERS.  IF THE INPUT
9327 REM STRING HAS TOO MANY FIELDS THE EXTRA FIELDS WILL
```

Listing 1 continued on page 182

Listing 1 continued:

```
9330 REM BE IGNORED.
9333 REM IF THE INPUT STRING HAS TOO FEW FIELDS THE EXTRA
9336 REM FIELDS WILL BE 'BLANKED' OR 'ZEROED'.  FOR
9339 REM BLANK FIELDS - ENTER '0' FOR NUMERIC  AND ONE BLANK
9342 REM ENCLOSED BY DELIMITERS FOR STRINGS.
9345 REM
9348 REM INPUT:
9351 REM   Z$       - INPUT STRING
9354 REM   Y(1,K)   - PARAMETER TABLE
9357 REM   Y9       - NO OF FIELDS INCLUDING BLANKS + 1
9360 REM   D$       - DELIMITER
9369 REM OUTPUT:
9372 REM   V$(1)    - STRING FIELDS ARRAY
9375 REM   V(1)     - NUMERIC FIELDS ARRAY
9376 REM   ERR      - 1-OK, 2-ERROR
9378 REM VARIABLE NAMES USED:
9381 REM   D$,V$(1),W$,X$,V(1),V1,V2,V3,V4,V5,V6,V7,Y9
9400 FOR V3=1 TO V1
9403 V$(V3)=""
9406 NEXT V3
9409 FOR V3=1 TO V2
9412 V(V3)=0
9415 NEXT V3
9416 REM   ANY DELIMITER MAY BE USED
9418 D$="#"
9421 V1=0
9424 V2=0
9427 V4=1
9430 V5=0
9433 V6=1
9434 W$=""
9435 ERR=1
9436 FOR V7=1 TO LEN(Z$)
9439 IF Y(1,V6)<>4 GOTO 9448
9442 V6=V6+1
9445 GOTO 9439
9448 X$=MID$(Z$,V7,1)
9451 IF X$<>D$ GOTO 9469
9454 V4=V4+1
9457 IF V7=LEN(Z$) GOTO 9515
9460 IF V4=2 GOTO 9545
9463 V4=1
9466 GOTO 9545
9469 IF X$=" " GOTO 9503
9472 V3=1
9475 IF Y(1,V6)=1 GOTO 9493
9478 IF X$>="0" AND X$<="9" GOTO 9493
9481 IF X$="-" GOTO 9493
9484 IF X$="." AND Y(1,V6)=3 GOTO 9493
9487 PRINT "FIELD (";V6;") NOT NUMERIC"
9490 ERR=2: RETURN
9493 V5=V5+1
9494 IF V5>INT(Y(3,V6)) GOTO 9545
9496 W$=W$+X$
9499 IF V7=LEN(Z$) GOTO 9512
9500 GOTO 9545
9503 IF V4=2 GOTO 9493
9506 IF V3=2 GOTO 9512
9509 V3=2
9512 IF Y(1,V6)<>1 GOTO 9524
9515 V1=V1+1
9518 V$(V1)=W$
9521 GOTO 9530
9524 V2=V2+1
9527 V(V2)=VAL(W$)
9530 V6=V6+1
9533 IF V7=LEN(Z$) GOTO 9548
9536 V5=0
9539 W$=""
9542 IF V6=Y9 GOTO 9548
9545 NEXT V7
9548 RETURN
9600 REM   FORMATTED OUTPUT SUBROUTINE [SUB I/O ID.0]
```

Listing 1 continued on page 184

Listing 1 continued:

```
9603 REM
9606 REM THIS ROUTINE ACCEPTS ARRAYS OF STRING AND NUMBER
9609 REM FIELDS AND PRODUCES A FORMATTED STRING RECORD
9612 REM BASED ON A TABLE BUILT INTO THE PROGRAM OR CREATED
9614 REM BY [SUB A/O TABLE BUILD PROGRAM].
9616 REM NUMBERS ARE RIGHT JUSTIFIED.  DECIMAL POSITION
9618 REM OF REAL NUMBERS ARE HELD AND TRAILING ZEROS ARE
9621 REM ADDED IF REQUIRED.
9622 REM
9624 REM INPUT:
9627 REM    V$(I)    - STRING FIELD ARRAY
9630 REM    V(I)     - NUMBER FIELD ARRAY
9633 REM    Y(I,K)   - PARAMETER TABLE
9636 REM    Y9       - NO OF FIELDS INCLUDING BLANKS + 1
9639 REM OUTPUT:
9642 REM    U$       - OUTPUT STRING RECORD
9645 REM VARIABLE NAMES USED
9648 REM    U$,V$(I),W$,Y$,V(I),V1,V2,V3,V4,V5,V6,V7,V8,V9,Y(I,K),Y9
9649 REM
9650 U$=""
9652 V1=0
9654 V2=0
9656 FOR V9=1 TO Y9-1
9658 W$=""
9660 V5=Y(1,V9)
9663 V3=INT(Y(3,V9))
9666 ON V5 GOTO 9668,9689,9689,9669
9668 V1=V1+1
9669 FOR V8=1 TO V3
9671 IF V5<>1 GOTO 9675
9672 Y$=MID$(V$(V1),V8,1)
9675 IF Y$="" OR V5=4 THEN Y$=" "
9678 IF V5=2 OR V5=3 THEN Y$="*"
9681 W$=W$+Y$
9684 NEXT V8
```

Listing 1 continued:

```
9685 U$=U$+W$
9687 GOTO 9760
9689 V2=V2+1
9690 V7=INT(V(V2))
9693 V7=LEN(STR$(V7))-1
9694 Y$=STR$(V(V2))
9696 IF LEFTS(Y$,1)="-" THEN V7=V7+1
9697 IF MID$(Y$,2,1)="." THEN V7=V7-1
9698 IF LEFTS(Y$,1)="-" GOTO 9701
9699 IF V(V2)>1.0 GOTO 9701
9700 V7=0.0
9701 IF LEFTS(Y$,1)<>"-" THEN Y$=MID$(Y$,2)
9703 V4=(Y(3,V9)*10)-(V3*10)
9706 IF V5=3 GOTO 9721
9708 IF V3-LEN(Y$)=0 GOTO 9716
9709 FOR V8=1 TO V3-LEN(Y$)
9712 W$=W$+" "
9715 NEXT V8
9716 W$=W$+Y$
9718 GOTO 9757
9721 IF V7-1>=V3-V4 GOTO 9669
9724 IF INT(V(V2))=V(V2) THEN Y$=Y$+"."
9727 V6=0
9728 V7=V4+V7+1
9729 V7=V3-V7
9731 FOR V8=1 TO V3
9733 IF INT(V7+.005)>(V8-1) GOTO 9748
9736 V6=V6+1
9739 V$=MID$(Y$,V6,1)
9742 IF V$="" THEN V$="0"
9743 W$=W$+V$
9745 GOTO 9754
9748 W$=W$+" "
9754 NEXT V8
9757 U$=U$+W$
9760 NEXT V9
9763 RETURN
9997 END
```

Copies of these routines are available for $5 on paper tape or Tarbell format cassettes for 8 K V3.1, 3.2 and 4.0 BASIC from Elliam Associates, 24000 Bessemer St, Woodland Hills CA 91367.

Record Description

Product Class	A2
Product Code	A6
Description	A15
Vendor Code	I3
Quantity On Order	I4
Quantity On Hand	I4
Sold Year To Date	I4
Unit Sales Price	F7.2

Format Statement

F$="(A2,A6,A15,I3,3I4,F7.2)"

Data Record

TW	HD110V	Tape Winder	107	45	37	123	27.00
V$(1)	V$(2)	V$(3)	V(1)	V(2)	V(3)	V(4)	V(5)

Table 1: Format statement and corresponding data record. The descriptions for formats used here are FORTRAN types. The product class is an alphanumeric quantity having two characters, the product code consists of six alphanumeric characters and the description of 15 characters. The particular vendor code is a 3 digit integer. The quantity on order, on hand and the number sold up to this date are all 4 digit integers. The unit sales price is a 7 digit floating point number with two digits after the decimal place and four digits before the decimal place.

Text continued from page 176:

tine. This is done with a FORTRAN type format statement which defines:

- A = Alphabetic or String Field.
- I = Integer Number.
- F = Floating Point or Real Number.
- X = Blank.

Table 1 shows how these formats are used.

The format definition routine takes the format string statement (F$) and converts it into a 3 column array (V). The first column defines the type of field: string, alphanumeric, integer, real, or blank. The second column provides the starting position of the field within the record. The third field provides the length of the field and number of decimal positions. This routine creates a parameter table that is used by the other routines.

The parameter table could also be built using values from DATA statements read into the proper variables thus eliminating the table build routine. Once the table is created, it can be used with INPUT, READ and PRINT statements to convert the input or output string into string and number array variables. Any number of formats may be used in a program, but the format definition routine must be rerun each time a different format is used.

Fixed Form Input

The normal action of BASIC requires an entry for each field listed as a variable with an INPUT statement. This is a nuisance when you have an input and output (IO) field record and the last five entries are blank most of the time. The fixed form input does not require that the trailing fields be entered, since they will be blanked or zero filled. It is sometimes easier to keep the keyed input in neat columns (fixed format) rather than following one field after another (normal BASIC).

Example:

Normal BASIC

```
14,16,98
1457,258,7
2,3,7
```

Fixed Format

```
  14  16 98
1457 258  7
   2   3  7
```

The main advantage is in inputting formatted records from cassette tape or floppy disk. (See formatted output section, para-

graph after next, for further discussion of external IO.)

Free Form Input

Now that formatted input has been presented, let's look at the advantages and disadvantages of free form input. The major advantage is that data fields need only be separated by a blank and the routine will reformat that field to its proper place in the input record. Strings and numbers may be intermixed, but strings containing leading blanks or blanks within the string must be enclosed with a delimiter. The routine delimiter is a pound sign (#), although any character might be used. Blank fields must also be enclosed with delimiters, and numeric fields require a zero. Each method has its advantages and drawbacks depending on the type of data being handled. An example is shown in table 2.

Table 2: In this example a free form input is read by a formatting routine and stored on a record as indicated.

```
Example:
  keyed input   TW HD110V #TAPE WINDER #107 45 123 27.0
  format        F$=" (A2,A6,A15,I3,3I4,F7.2)"
  record        TWHD100VTAPE WINDER    107  45  123  27.00
```

Table 3: Examples of how the format will affect the data that is being output. Note that some of the resulting output formats are indented. This is a result of leading blanks created to satisfy the format requirements for certain cases.

Data Format	Format Statement	Output Format
ABCDE	A6	ABCDE
ABCDEFG	A6	ABCDEF
123	I4	123
12345	I4	****
12.34	F6.2	12.34
12.3475	F6.2	12.35
12.	F6.2	12.00
11234.1	F6.2	******

Formatted Output

The formatted output routine uses the parameter table values and the variable array values in the V array and places them in the output string. Blanks as called out in the format statement are included. Strings are left justified (start in the first position of the field) and numeric values are right justified (any spaces appear on the left). Numeric values larger than the field call out cause the field to be filled with asterisks. Floating point (real) numbers with fewer than the required decimal places are zero filled. Numbers with more decimal places than the format allows are rounded as shown in table 3. Taking table 2 as an example input, the data could be printed with a different format such as in table 4.

About the Routines

The line numbers used by these routines are set high (above location 9000 in memory) so that BASIC programs can be written under them. Care must be taken that your programs do not have line numbers higher than 9000. All of the variable names used in each routine are listed in the comments. These variable names must not be used in your programs. All the comments are included before the routines so they may be deleted to save space.

More About Records

Obviously, it takes only a minimum amount of extra code to switch fields, add string constants and perform mathematical functions. Using the input data record of table 1, the transformations in table 5 may be made.

Once these routines are in your library, it is a simple matter to load them into memory, to key in your program and to add format statements.■

Table 4: Format and example output using the format and the data in table 3.

```
F$="(A2,X,A6,X,A15,I3,3I5,F8.3)"
TW HD100V Tape Winder    107   45   37  123    27.00
```

Table 5: Some typical transformations that may be performed on the stored and formatted data. The last line is the result of these transformations using the given format.

V$(1)="Retail Value O/H"		change a string
V$(2)=V$(3)		move a string
V(1)=V(3)*V(5)		calculate a value
F$="(A16,2X,A15,F8.2)"		format
Retail Value O/H Tape Winder	199.00	output record

Book Reviews

Let's Talk LISP

by Laurent Siklossy
Prentice-Hall,
Englewood Cliffs NJ 1976
237 pages hardcover
$14.20

Let's Talk LISP is a fun and useful book to read, at least for those of us who learn best when the material is presented in an interesting way. This is especially helpful for LISP, because for someone who is familiar with traditional programming languages, LISP seems very peculiar at first. After reading *Let's Talk LISP* and writing a few programs, I wondered how I had managed to avoid LISP for so long.

The structure of the book is extremely straightforward. The first two chapters introduce the fundamental building blocks of LISP. After that, the reader is led through function definitions, recursion, MAP functions, and assorted elements of the language. Midway through the book, the author demonstrates how to write a LISP interpreter in LISP, and discusses the storage functions of LISP. At this point the reader has been introduced to almost everything in the language, but is probably not certain how to write a program. The remainder of the book consists of programming examples.

The first question which one should ask of a LISP book is how it treats language variations; LISP is not standardized. There are two major dialects (EVAL and EVALQUOTE), and many variations between implementations of the same dialect. The author discusses both of the major dialects, and points out where implementations are likely to differ. I have used two versions of LISP: a large version running on an Amdahl 470 and a Z80 version which was adapted from *Dr Dobb's Journal of Computer Calisthenics and Orthodontia,* number 30. Neither of these implementations matched the language used in *Let's Talk LISP,* but neither of them required much work to make the sample programs run. In short, the book attempts to cover possible differences, and gets most of them, but unless you are using MACLISP at MIT, you will have to make some changes.

If you want to learn LISP and you are not turned off by a lighthearted but thorough treatment of the subject, *Let's Talk LISP* is a good book to read.

John A Lehman
716 Hutchins #2
Ann Arbor MI 48103

Gödel, Escher, Bach: An Eternal Golden Braid

Douglas R Hofstadter
Basic Books
New York 1979
742 pages plus notes and references, hardcover
$18.95

Gödel, Escher, Bach is a book of youthful wisdom and deep beauty. It spans the domains of art, science and philosophy — a fact which evidently causes considerable consternation to book store clerks, who occasionally misshelve it with the "occult."

At some fundamental level, the works of Bach, Escher and Gödel may be seen as variant manifestations of a single common theme. Hofstadter uses this theme of recursion or self-reference to unify his exploration of questions and issues from such apparently disparate fields as artificial intelligence and molecular biology.

Gödel, Escher, Bach is an enchanting book, in the same sense that Lewis Carroll's writings are enchanting. Although Hofstadter, a contemporary American, writes more idiomatically and with less polish than Lewis Carroll, the book's childlike exuberance, together with artistic forms, whimsical passages and concealed meanings, make it a sheer delight. The entire book has the form of a fugue — it *is* what it is about. Prose and dialogues alternate. The latter are in the spirit of Lewis Carroll and each imitates the form of a particular Bach composition.

Hofstadter is a physicist by training and a computer scientist by vocation. Students of artificial intelligence will appreciate his deeply knowledgeable treatment of this subject. Of particular interest are his remarks concerning

representations of knowledge, and his speculations concerning the future of artificial intelligence. For example,

"Question: Will a computer program ever write beautiful music? Speculation: Yes, but not soon. Music is a language of emotions, and until programs have emotions as complex as ours, there is no way a program will write anything beautiful . . . To think — and I have heard this suggested — that we might soon be able to command a preprogrammed mass-produced mail-order twenty-dollar desk-model 'music box' to bring forth from its sterile circuitry pieces which Chopin or Bach might have written had they lived longer is a grotesque and shameful misestimation of the depth of the human spirit . . ."

Psychologists and other scientists who study humans are customarily reluctant to deal with such elusive topics as "consciousness" or "free will." Hofstadter has no such reticence, and consequently contributes unique and appealing insights to these subjects. In view of the book's global frame of reference, it is important to stress that the author is not reckless. On the contrary, one of his topics concerns the "nature of evidence," and in this regard it is clear that his own implicit criteria of acceptable evidence are definitely conservative. Neither is he a bigot, scientific or otherwise. His approach to centuries-old problems and dilemmas is characterized by carefulness and fair-mindedness.

An interesting paradox arises from the observation that no two human brains are perfectly isomorphic; yet humans have a powerful ability to communicate with other humans, however remote in time or place. Hofstadter invents the concept of a "partial software isomorphism" between the brains of people who have similar thinking styles. An analysis of "Jabberwocky" translations clearly reveals the impossibility of exact translation between even closely related languages. One cannot help thinking that Hofstadter's book itself must represent the ultimate challenge for a translator. The dialogues not infrequently contain more than two levels of meaning. There are puns and acrostics, word puzzles and number puzzles — indeed, levels of meaning sometimes communicate with one another.

Although the prose is tractable, it is manifestly impossible to convey the true flavor of the book or to completely describe its subject matter in a brief review. Perhaps the best synopsis is found in the book on page 370, where the author diagrams a "tiny portion" of his "semantic network." This "tiny portion" contains more than 100 interrelated symbols including: Truth vs provability, Gödel code, Genetic code, Recursion, Figure vs ground, Escher, Canons and fugues, RICERCAR, Holism vs reductionism, Minds, Computers, Turing and more. What Hofstadter has to say on these subjects is uniquely interesting because it is founded on knowledge, derived by honest (unprejudiced) reasoning and expressed with a simple lucidity.

In the past few decades, much has been said and written about "intelligence," a concept now suspect but once thought to have a clear intuitive meaning. Whatever human intelligence is, one feels that this book manifests its highest qualities. *Gödel, Escher, Bach* is an exceptionally good book.■

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A Financial Analysis Program

John A Lehman
716 Hutchins #2
Ann Arbor MI 48103

Introduction

Financial analysis, as it will be used in this article, means the study and analysis of financial statements. Financial statements are the documents which are produced by an accounting system; they report the position of a firm (such as the balance sheets shown in table 1) and how well it has done over the last period (income statements). They are used both by small businesses and by major corporations. The latter are required to make public statements in annual reports and in filings with the Securities and Exchange Commission; these statements serve as one of the primary sources of information to investors.

The program logic described in figure 1 is versatile enough to work on the financial statements of almost any company, although some statements may first need to be consolidated a bit. The basic tools used to analyze statements are ratios and percentages. These can be calculated for a firm, and then compared with both the firm's previous performance and with other firms in the same industry. In this way, a comprehensive study can evaluate the position of the firm and identify trends in performance.

There are a number of different people who can make use of this sort of analysis. Investors form a major group. Those who wish to make their own investment decisions rather than follow the suggestions of a broker or other advisor, usually want to base their investments on something more than blind faith. The analysis of financial statements is a good way to begin evaluating prospective investments. Unfortunately, many investors wish to evaluate a fairly large number of possibilities. This may present problems because the detailed analysis of ratios and percentages needed to evaluate your investments requires a great deal of time to calculate. This is where the personal computer comes in. With this program, you can evaluate a set of detailed reports in about the same time it takes to calculate a simple percentage analysis with a calculator. The results may be used as is, or used as inputs to any statistical calculations which you wish to use. In short, a personal computer can significantly reduce the time spent on the tedious calculations involved in financial analysis, and leave the analyst more time for creative thought.

Investors are not the only ones who can use this sort of program. Banks regularly use ratio and percentage analysis to evaluate loan applications from businesses. Many banks are well equipped with computing facilities. But the businessman who is applying for the loan is often not. A banker is likely to be impressed if the financial statements submitted with the loan application include ratios and percentages. Not only does it make the banker's job easier, but it indicates that the applicant is well prepared.

A pro forma statement is a useful indicator to provide. These are forecasts of your financial position at some future point (eg: when the loan falls due). The program will also calculate pro formas.

Aside from using all of these financial indicators to impress the bank, a small businessman might want to use them to analyze his business. Where are things going well, and what weaknesses could stand some attention? There is plenty of available documentation which shows how to interpret ratios and percentages, but again, the calculations are tedious.

This program might also prove useful for the financial analyst— professional or academic. Since I count myself in the latter category, I have

About the Author
John A Lehman is a doctoral student in business administration at the University of Michigan.

Table 1: *The financial statements from the MITS corporation before it was absorbed. These figures come from the* Annual Report. *This illustrates the format used in a standard financial report.*

MITS INC

Balance Sheet

December 31 1975 and 1974

Assets

	1975	1974
Current Assets:		
Cash	$ 112,461	$ 30,596
Accounts receivable, less allowance for doubtful accounts of $5,500, $2,500 in 1974 (Note 2)	258,790	35,808
Notes receivable, stockholder	350	350
Inventories (Note 2)	640,432	266,219
Current portion of prepaid expenses	104,809	33,986
Total current assets	1,116,842	366,959
Property, plant and equipment (at cost) (Notes 2 and 3):		
Tooling	225,821	117,669
Transportation	130,607	8,140
Shop equipment	55,150	13,349
Office equipment	40,305	24,931
Leasehold improvements	12,749	9,848
Drafting equipment	5,753	2,694
	470,385	176,631
Less accumulated depreciation	119,248	58,233
	351,137	118,398
Other assets:		
Deposits	1,766	240
Deferred portion of prepaid expenses	29,938	—
	31,704	240
	$ 1,499,683	$ 485,597

See accompanying accountants' report and notes to financial statements.

Liabilities and Stockholders' Equity (Deficit)

	1975	1974
Current liabilities:		
Accounts payable - trade	$ 331,791	$ 171,279
Customer deposits	455,425	85,517
Working capital loans (Note 2)	321,463	406,963
Current portion of long-term debt (Note 3)	39,288	8,602
Accrued liabilities	83,327	17,944
Total current liabilities	1,231,294	690,305
Deferred portion of long-term debt (Note 3)	118,626	1,080
Commitments (Note 4)		
Stockholders' equity:		
Common stock, $.01 par value, 25,000,000 shares authorized, 947,495 shares issued in 1975, 902,940 shares issued in 1974	9,475	9,029
Additional paid-in capital	294,683	250,575
Retained deficit	(153,295)	(465,392)
	150,863	(205,788)
Less treasury stock, at cost, 1,100 shares	1,100	—
	149,763	(205,788)
	$ 1,499,683	$ 485,597

Table 1 continued on page 194

Table 1 continued:

MITS INC

Statement of Income (Loss)

Years ended December 31 1975 and 1974

	1975	1974
Sales	$ 3,240,772	$ 959,972
Cost of sales	2,112,551	794,579
Gross profit	1,128,221	165,393
Expenses:		
Selling	441,596	152,407
Administrative	265,274	176,295
Other income and deductions	109,254	50,795
	816,124	379,497
Net income (loss)	$312,097	$ (214,104)
Net income (loss) per common share	$ .33	$ (.24)

See accompanying accountants' report and notes to financial statements.

no doubt that the program is indeed useful for such people. I wrote this program to handle analytical problems which I had to perform quite often. Again, the outputs from this program may be used as they are, or as inputs to additional analyses.

Overview of the Program

The program in listing 1 is set up to work on standard financial statements with data for up to ten periods. It is arranged to use a standard chart of accounts for the income statement and balance sheet. Since the chart of accounts is not very specific, more detailed statements will have to be condensed first. This would be necessary for analysis in any case, since ratios are not usually calculated on the basis of all of the different categories of inventory, etc. The ten periods allowed may be either in years or quarters, and the output will be labeled correspondingly. Ten periods were selected since many annual reports and other published financial statements include ten-year summaries.

For whichever periods are entered, the user may select either a ratio analysis, a percentage analysis, or both. The ratio analysis subroutine calculates fourteen different ratios.

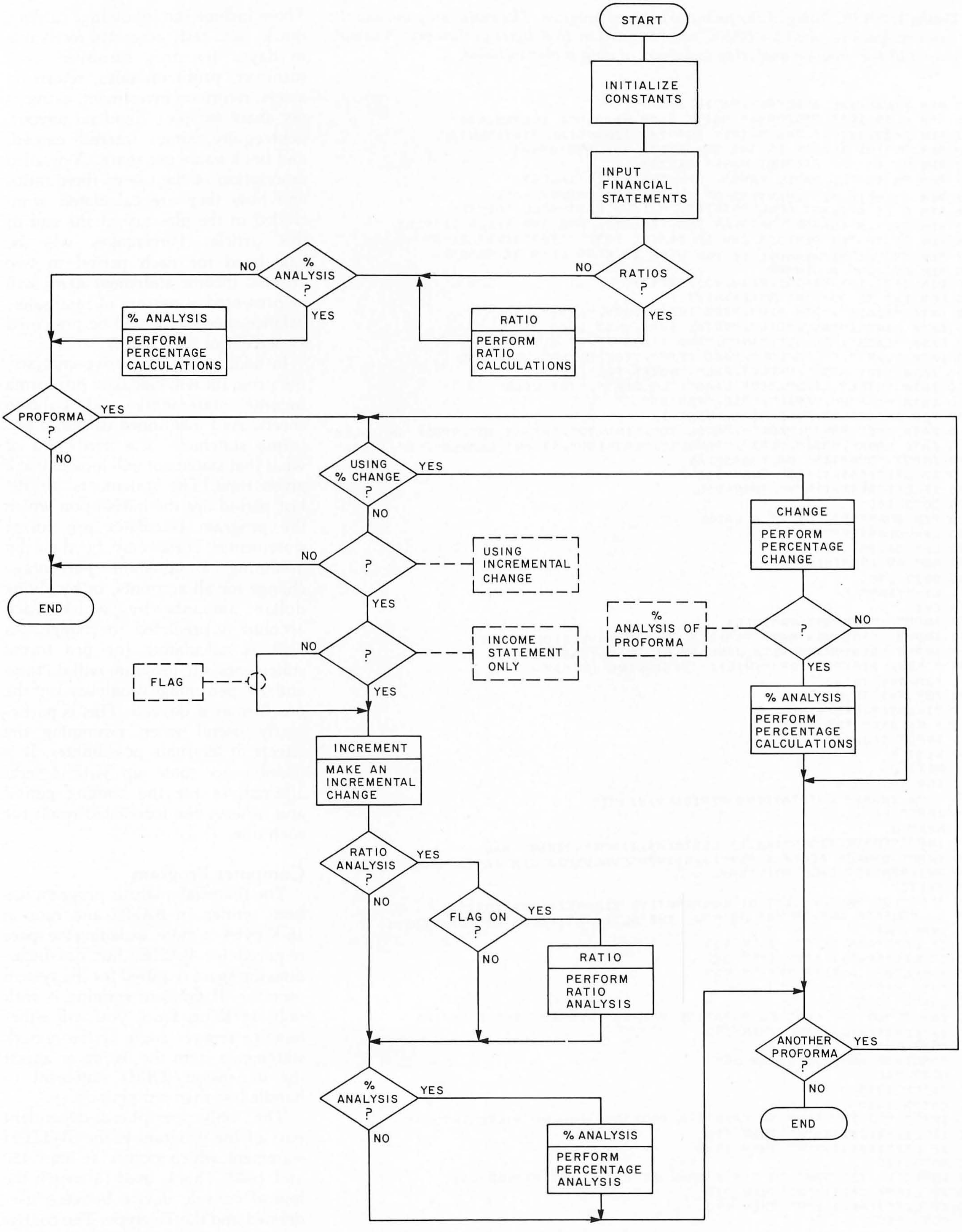


Figure 1: *Flowchart of the financial analysis program.*

Listing 1: *BASIC listing of the financial analysis program. The entire program and the memory space required for BASIC can be stored in 16 K bytes of memory. A sample output of the program analyzing two years of data is also included.*

```
10 REM FINANCIAL ANALYSIS,RATIO & %
20 REM ALSO DOES PROFORMAS USING % OR ABSOLUTE INCREMENTS
21 REM Z(33,11) IS THE MATRIX FOR THE FINANCIAL STATEMENTS
22 REM PERIOD ELEVEN IS THE SPACE FOR THE PROFORMAS
23 REM N$ IS THE ACCOUNT NAMES VECTOR
24 REM R$ IS THE RATIO NAMES, R() THE RATIO VALUES
25 REM Q INDICATES QUARTERS OR YEARS, C$=COMPANY NAME
26 REM B IS A FIRST CELL POINTER, M IS A LAST CELL POINTER
27 REM SWITCH CHANGES BETWEEN THE TELETYPE AND THE VIDEO DISPLAY
28 REM UP TO TEN PERIODS CAN BE TESTED FOR.  STATEMENTS 21-29
29 REM SHOULD BE REMOVED IF YOU HAVE 16 K OR LESS OF MEMORY.
30 REM BY JOHN A LEHMAN
40 DIM Z(33,10),N$(33),R(13,13),R$(13)
50 FOR I=1 TO 33:READ N$(I):NEXT I
60 DATA "SALES","OTH REV","TOT INC","CGS","DEPR","SGA"
70 DATA "INT","TAX","DIV","TOTAL EXP","NET INC"
80 DATA "CASH","RCBLS","INV","PPD ITEMS","TOT CUR"
90 DATA "LAND","BLDG/EQU","ACC DEPR","TOT FIXED","OTH AS"
100 DATA "TOT ASTS","ACCTS PBL","NOTES PBL","CUR LT"
110 DATA "OTHER LIAB","CUR LIAB","LT DEBT","TOT LIAB"
120 DATA "C STK","APIC","RE","TOT CR"
130 FOR I=1 TO 13:READ R$(I):NEXT I
140 DATA  "CURRENT","ACID","RCBL TO","INV TO","ASSET TO","PROF ON SALES"
150 DATA "ROA","ROI","EPS","PAYOUT","EBT-EQU","T INT EARNED","BK/SHARE"
160 INPUT "QUARTERS OR YEARS";A$
170 IF LEFT$(A$,1)="Q" THEN 210
180 IF LEFT$(A$,1)="Y" THEN 250
190 GOTO 160
200 REM QUARTERS. L$ IS A LABEL
210 L$="QUARTERS"
220 LET Q=.25
230 REM AN INCREMENT
240 GOTO 270
250 L$="YEARS "
260 Q=1
270 INPUT  "COMPANY NAME";C$
280 INPUT  "FOR HOW MANY PERIODS DO YOU HAVE FIGURES";N
290 INPUT "BEGINNING WITH JANUARY OF WHAT YEAR";Y
300 ? "OK, FIGURES FOR ";N;L$;" BEGINNING IN ";Y
310 FOR J=1 TO 33
320 FOR K=1 TO N
330 Y1=INT(Y+Q*K-1)
340 ? N$(J);" FOR ";Y1
350 INPUT Z(J,K)
360 NEXT K
370 NEXT J
380 FOR J=1 TO N
390 ? "# SHARES OUTSTANDING PERIOD ";J; "?"
400 INPUT H(J)
410 NEXT J
420 INPUT"CORRECTIONS";A$:IF LEFT$(A$,1)="N"  THEN  440
430 INPUT "WHICH ACCT# & PD#";J,K:INPUT"VALUE";Z(J,K):GOTO 420
440 B=1:REM 1ST CELL POINTER
450 SWITCH
460 ?"DO YOU WANT A LIST OF COMPARATIVE FINANCIAL RATIOS?"
470 ?  "PLEASE ANSWER YES OR NO.  THE ALTERNATIVE IS COMPARATIVE %"
480 INPUT A$
490 IF LEFT$(A$,1)="Y" THEN 530
500 IF LEFT$(A$,1)="N" THEN 540
510 ? "PLEASE ANSWER YES OR NO"
520 GOTO 460
530 GOSUB 1030
540 INPUT "DO YOU WANT COMPARATIVE % FROM INCOMES STMT & BS";A$
550 IF LEFT$(A$,1)="Y" THEN 590
560 GOTO 940
570 ?"PLEASE ANSWER YES OR NO"
580 GOTO 540
590 GOSUB 1310
600 GOSUB 1410
610 INPUT "DO YOU WANT TO CREATE A PROFORMA INCOME STATEMENT";A$
620 IF LEFT$(A$,1)="Y" THEN 650
630 IF LEFT$(A$,1)="N" THEN 1840
640 GOTO 610
650 INPUT"DO YOU WANT TO USE % CHANGES FROM LAST PERIOD";A$
660 IF LEFT$(A$,1)="N" THEN 710
670 IF LEFT$(A$,1)="Y" THEN 690
680 GOTO 650
690 GOSUB 1510
700 GOTO 940
```

Listing 1 continued on page 198

These include the following: current, quick, acid test, accounts receivable in days, inventory turnover, asset turnover, profit on sales, return on assets, return on investment, earnings per share (simple), dividend payout, debt/equity, times interest earned, and book value per share. A detailed description of the use of these ratios and how they are calculated is included in the glossary at the end of this article. Percentages will be calculated for each period in two groups. Income statement items will be presented as percent of total sales; balance sheet items will be presented as percent of total assets.

In addition to the above analyses, the program will calculate pro forma income statements and balance sheets. As I mentioned earlier, a pro forma statement is a prediction of what that statement will look like at a given time. The statements for the last period are the basis upon which the program calculates pro forma statements. These may be done by assuming a constant percentage change for all accounts, or by giving dollar amounts by which each account is predicted to change. As well as calculating the pro forma statements, the program will do ratio and/or percentage analyses on the pro formas if desired. This is particularly useful when examining the effects of alternate possibilities. It is possible to come up with several alternatives for the coming period and observe the forecasted result for each one.

Computer Program

The financial analysis program has been written in BASIC and runs in 16 K bytes or more, including the space required for BASIC, but not including the space required for the system monitor. If you are running it with only 16 K (as I do) you will either have to remove some of the remark statements from the listing or adjust the dimension (DIM) statement to handle less than ten periods.

The only peripheral-dependent part of the program is the SWITCH statement which occurs at lines 450 and 1840. This is used to switch the logical console device between user defined and the Teletype. The configuration upon which I run it allows me to set up all of the statements

Listing 1 continued:

```
710 ? "DO YOU WANT TO MAKE INCREMENTAL CHANGES FROM"
720 INPUT "THE LAST PERIOD USING AMOUNTS OF CHANGE";A$
730 IF LEFT$(A$,1)="N" THEN 860
740 IF LEFT$(A$,1)="Y" THEN 770
750 ? "PLEASE ANSWER YES OR NO"
760 GOTO 710
770 ?  "DO YOU WANT JUST THE INCOME STATEMENT (ENTER IS)  OR"
780 INPUT"INCOME STATEMENT+BALANCE SHEET (ENTER ANYTHING ELSE)";Z$
790 IF Z$="IS" THEN 840
800 F=33
810 REM  POINTS TO LAST ACCOUNT TO BE USED
820 GOSUB 1700
830 GOTO  860
840 F=11
850 GOSUB 1700
860 INPUT "DO YOU WANT A RATIO ANALYSIS OF THE PROFORMA (IF ANY)";A$
870 IF LEFT$(A$,1)="Y" THEN 890
880 IF LEFT$(A$,1)="N" THEN 940
890 LET N=1
900 IF Z$<>"IS" THEN 930
910 ?"CAN'T CALC WITH JUST INC STATEMENT"
920 GOTO 940
930 GOSUB 1030
940 INPUT "DO YOU WANT A % ANALYSIS OF THE PROFORMA";A$
950 IF LEFT$(A$,1)="Y" THEN 980
960 IF LEFT$(A$,1)="N" THEN 1000
970 GOTO 940
980 N=M
990 GOSUB 1310
1000 INPUT "DO YOU WANT ANOTHER PROFORMA";A$
1010 IF LEFT$(A$,1)="Y" THEN 650
1020 IF LEFT$(A$,1)="N" THEN 1840
1030 REM SUBROUTINE TO CALCULATE RATIOS
1040 FOR I=B TO N
1050 R(1,I)=Z(16,I)/Z(27,I):REM CURRENT RATIO
1060 R(2,I)=(Z(12,I)+Z(13,I))/Z(27,I):REM ACID TEST
1070 R(3,I)=365/(Z(1,I)/Z(13,I)):REM RCBL DAYS
1080 R(4,I)=365/(Z(4,I)/Z(14,I)):REM INV TO
1090 R(5,I)=Z(1,I)/Z(22,I):REM ASSET TO
1100 R(6,I)=Z(11,I)/Z(1,I):REM PROFIT ON SALES
1110 R(7,I)=Z(11,I)/Z(22,I):REM ROA
1120 R(8,I)=Z(11,I)/(Z(33,I)-Z(29,I)):REM ROI
1130 R(9,I)=Z(11,I)/H(I):REM EPS
1140 R(10,I)=Z(9,I)/Z(11,I):REM DIV PO
1150 R(11,I)=Z(29,I)/Z(22,I):REM D/E
1160 R(12,I)=(Z(11,I)+Z(9,I)+Z(8,I)+Z(7,I))/Z(7,I):REM T.I.E
1170 R(13,I)=(Z(33,I)-Z(29,I))/H(I):REM BK/SHARE
1180 NEXT I
1190 INPUT"MOVE PAPER TO TOP OF PAGE & PRESS A KEY";A$
1200 ? C$,"RATIO ANALYSIS":?
1210 ? "RATIOS FOR ";N;L$;" BEGINNING IN ";Y:?
1220 FOR I=1 TO 13
1230 ? R$(I)
1240 FOR J=B TO N
1250 Y1=INT(Y+Q*J-1)
1260 ? Y1,R(I,J)
1270 NEXT J
1280 NEXT I:?:?:?
1290 RETURN
1300 REM  SUBROUTINE TO DO % ANALYSIS
1310 INPUT "MOVE PAPER TO TOP OF PAGE & PRESS A KEY";A$
1320 ?  "INCOME STATEMENT ITEMS AS % OF TOTAL INCOME"
1330 FOR I=1TO11
1340 ? N$(I)
1350 FOR J=B TO N
1360 Y1=INT(Y+Q*J-1)
1370 R(J,1)=Z(I,J)/Z(3,J)*100
1380 ? Y1,R(J,1):NEXTJ
1390 NEXT I:?
1400 RETURN
1410 ? "B.S. ITEMS AS % OF TOTAL ASSETS":?
1420 FOR I=12 TO 33
1430 ? N$(I),
1440 FOR J=1 TO N
1450 Y1=INT(Y+Q*J-1)
1460 R(J,1)=Z(I,J)/Z(22,J)*100
1470 ? Y1,R(J,1):NEXT J
1480 NEXT I:?:?:?
1490 RETURN
1500 REM SUBROUTINE TO CALCULATE PROFORMA WITH % CHANGES
1510 M=N+1:REM SAVE LAST CELL POINTER
1520 B=M
1530 FOR I=1TO9
1540 ? "CHANGE FOR ";N$(I)
```

Listing 1 continued on page 200

using a video display and then have the results printed on the Teletype. If your system does not allow for the SWITCH command, you can leave it out with no ill effects.

If you have more than 16 K bytes of memory, you may want to extend the strings from lines 60 thru 120 and 140 thru 150. This will make the output more readable.

Glossary

accounts receivable in days: *Accounts receivable are divided by total sales to produce receivable turnover per year, then divided by 365. This gives some indication of how fast receivables are being collected. Values vary with industry. Generally, the lower the number of days, the better.*

asset turnover: *Net sales divided by average total assets. This is one indication of how well assets are being used.*

book value per share: *Common stock divided by the number of shares. How much the shares of stock are worth in an accounting sense.*

current ratio: *A current account is cash or anything which can be converted into cash within one year. The current ratio is obtained by dividing the current assets by current liabilities. If the ratio is one, debts which must be paid within one year are just covered by assets which are expected to be received within one year. To maintain financial peace of mind the current ratio should be greater than one.*

debt/equity ratio: *Total liabilities divided by total assets (also referred to as total equities). How much of the firm's capital was furnished by creditors as opposed to owners. It varies by industry, but the lower the better for safety, and the higher the better for earnings per share. This contradiction is due to something called leverage, which is a fancy term for investing other people's money and keeping the profits.*

dividend payout: *Cash dividends divided by net income. This shows how much of earnings were paid to investors as opposed to those kept for*

Listing 1 continued:

```
1550 INPUT P
1560 Z(I,M)=Z(I,(M-1))*(1+(P/100))
1570 NEXT I
1580 LET Z(3,M)=Z(1,M)+Z(2,M)
1590 Z(10,M)=0
1600 FOR I=4 TO 8
1610 LET Z(10,M)=Z(10,M)+Z(I,M)
1620 Z(11,M)=Z(3,M)-Z(10,M)
1630 NEXT I
1640 INPUT"MOVE PAPER TO TOP OF PAGE AND PRESS A KEY";A$
1650 ? C$:?
1660 FOR I=1 TO 11
1670 ? N$(I),Z(I,M)
1680 NEXT I:?:?:?
1690 RETURN
1700 REM CALCULATE PROFORMA WITH INCREMENTALS
1710 M=N+1
1720 B=M
1730 FOR I=1 TO F
1740 ?"AMOUNT OF CHANGE FOR ";N$(I)
1750 INPUT P
1760 LET Z(I,M)=Z(I,(M-1))+P
1770 NEXT I
1780 INPUT"MOVE PAPER TO TOP OF PAGE & PRESS A KEY";A$
1790 ? C$:?
1800 FOR I=1TOF
1810 ? N$(I),Z(I,M)
1820 NEXT I:?:?:?
1830 RETURN
1840 SWITCH
1850 END
```

```
DO YOU WANT A LIST OF COMPARATIVE FINANCIAL RATIOS?
PLEASE ANSWER YES OR NO.   THE ALTERNATIVE IS COMPARATIVE %
? YES
MOVE PAPER TO TOP OF PAGE & PRESS A KEY?
                                                    K
MITS           RATIO ANALYSIS

RATIOS FOR  2 YEARS  BEGINNING IN   1974

CURRENT
 1974          .53159
 1975          .907047
ACID
 1974          .0961952
 1975          .301513
RCBL TO
 1974          13.6149
 1975          29.1469
INV TO
 1974          122.291
 1975          110.652
ASSET TO
 1974          1.97689
 1975          2.16097
PROF ON SALES
 1974         -.223032
 1975          .0963033
ROA
 1974         -.440909
 1975          .208109
ROI
 1974          1.04041
 1975          2.08394
EPS
 1974         -.237236
 1975          .329392
PAYOUT
 1974          0
 1975          0
EBT-EQU
 1974          1.42378
 1975          .900137
T INT EARNED
 1974         -6.1368
 1975          8.80243
BK/SHARE
 1974         -.228021
 1975          .158062
```

Listing 1 continued on page 201

use by the firm. This should be high for an income stock and low for a growth stock (all other things being equal).

earnings per share: *How much the firm made per share of common stock. Often this and the price/earnings ratio are the only things investors look at. There are actually two ways of calculating the earnings per share ratio; the more complicated one would require a program much longer than that provided in this article. Both types of earnings per share ratios are required in annual reports, so it is best to rely on both for needed information if a firm has a complicated capital structure.*

inventory turnover: *The cost of goods sold is divided by average inventory, and this is divided by 365.*

profit on sales: *Net income divided by net sales. This provides a very conservative estimate of profits. Therefore, it is frequently used when companies wish to appear as though they are not making much of a profit.*

quick ratio (acid test): *Unlike the current ratio, the quick ratio does not consider inventory and prepaid expenses as current assets. The quick ratio takes cash, marketable securities, and accounts receivable, and divides these by current liabilities. The result is the proportion of liabilities falling due within one year, which can be covered by assets sure to be worth cash. It is normally a little less than one.*

return on assets: *Net income divided by average total assets. How much you are making on what you have to make it with. As with any profit measure, the higher the better.*

return on investment: *Net income divided by the quantity assets minus liabilities. This shows how much the firm made on what the owners put into it. Assets which were bought with borrowed money are not included in the base.*

times interest earned: *The quantity of net income plus interest and tax payments divided by interest charges. This indicates how much more the firm made than was required to pay the interest on its debt. A firm which has a times interest earned ratio of less than one is bankrupt.*

Listing 1 continued:

```
DO YOU WANT COMPARATIVE % FROM INCOMES STMT & BS?  YES

 MOVE PAPER TO TOP OF PAGE & PRESS A KEY?

                                                    K
INCOME STATEMENT ITEMS AS % OF TOTAL INCOME
SALES
 1974           100
 1975           100
OTH REV
 1974           0
 1975           0
TOT INC
 1974           100
 1975           100
CGS
 1974           82.7711
 1975           65.1867
DEPR
 1974           2.08339
 1975           1.88227
SGA
 1974           34.2408
 1975           21.8118
INT
 1974           3.12509
 1975           1.23427
TAX
 1974           0
 1975           0
DIV
 1974           0
 1975           0
TOTAL EXP
 1974           39.5321
 1975           25.183
NET INC
 1974          -22.3032
 1975           9.63033

B.S. ITEMS AS % OF TOTAL ASSETS

CASH
 1974           6.3007
 1975           7.49898
RCBLS
 1974           7.37402
 1975           17.2563
INV
 1974           54.823
 1975           42.7045
PPD ITEMS
 1974           6.99943
 1975           6.98874
TOT CUR
 1974           75.5686
 1975           74.4719
LAND
 1974           0
 1975           0
BLDG/EQU
 1974           36.374
 1975           31.3656
ACC DEPR
 1974           11.992
 1975           7.95155
TOT FIXED
 1974           24.382
 1975           23.4141
OTH AS
 1974           .0494237
 1975           2.11405
TOT ASTS
 1974           100
 1975           100
ACCTS PBL
 1974           35.2718
 1975           22.1241
NOTES PBL
 1974           83.8067
 1975           21.4354
CUR LT
 1974           1.77143
 1975           2.61975
OTHER LIAB
 1974           21.3059
 1975           35.9244
CUR LIAB
 1974           142.156
 1975           82.1036
LT DEBT
 1974           .222407
 1975           7.91007
TOT LIAB
 1974           142.378
 1975           90.0137
C STK
 1974           1.85936
 1975           .6318
APIC
 1974           51.6014
 1975           19.6497
RE
 1974          -95.8391
 1975          -10.2218
TOT CR
 1974           100
 1975           100


DO YOU WANT TO CREATE A PROFORMA INCOME STATEMENT? YES
DO YOU WANT TO USE % CHANGES FROM LAST PERIOD? YES
CHANGE FOR SALES
? 100
CHANGE FOR OTH REV
? 0
CHANGE FOR TOT INC
? 100
CHANGE FOR CGS
? 50
CHANGE FOR DEPR
? 50
CHANGE FOR SGA
? 50
CHANGE FOR INT
? 50
CHANGE FOR TAX
? 50
CHANGE FOR DIV
? 50
MOVE PAPER TO TOP OF PAGE AND PRESS A KEY?

MITS

SALES           6.48154E+06
OTH REV         0
TOT INC.        6.48154E+06
CGS             3.16883E+06
DEPR            91500
SGA             1.06031E+06
INT             60000
TAX             0
DIV             0
TOTAL EXP       4.38063E+06
NET INC         2.10091E+06


DO YOU WANT A % ANALYSIS OF THE PROFORMA? YES
MOVE PAPER TO TOP OF PAGE & PRESS A KEY?
                                                   K
INCOME STATEMENT ITEMS AS % OF TOTAL INCOME
SALES
 1976           100
OTH REV
 1976           0
TOT INC
 1976           100
CGS
 1976           48.89
DEPR
 1976           1.4117
SGA
 1976           16.3588
INT
 1976           .925705
TAX
 1976           0
DIV
 1976           0
TOTAL EXP
 1976           67.5862
NET INC
 1976           32.4138

DO YOU WANT ANOTHER PROFORMA? NO
```

■

Another Plotter to Toy With, Revisited

Design and Construction Details

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502 Washington Ave
Wilmette IL 60091

Following the suggestion of Peter Lucas in the February 1979 issue of BYTE ("Another Plotter to Toy With," page 66) I built a plotter using an Etch-A-Sketch and two stepper motors. After solving the interface problem, I connected it to an I/O (input/output) port on my KIM-1 which is equipped with a teletypewriter, 8 K bytes of extra memory, and Tiny BASIC. Photo 1 shows the result: stepper motors mounted on the Etch-A-Sketch, along with a circuit board. The KIM-1 controls the apparatus using 4 bits of an I/O port. The stepper motors can be driven by any other computer having 4 bits of transistor-transistor logic (TTL) level output available.

The Etch-A-Sketch proved to be able to draw bar graphs with excellent results, drawing an even, horizontal baseline, while accurately reproducing data from the computer's memory. I later tried geometric figures, including a parabola. Because each step is only 0.0085 inches (0.216 mm), the device gives good approximations of curves. The main limitation of my plotting system resides in the inability of Tiny BASIC to handle fractional numeric values.

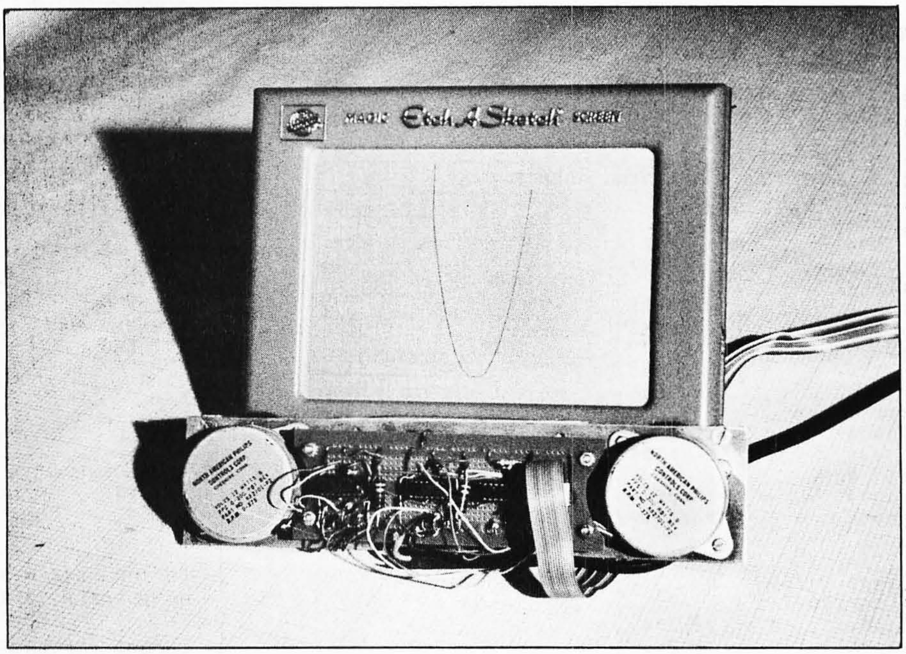


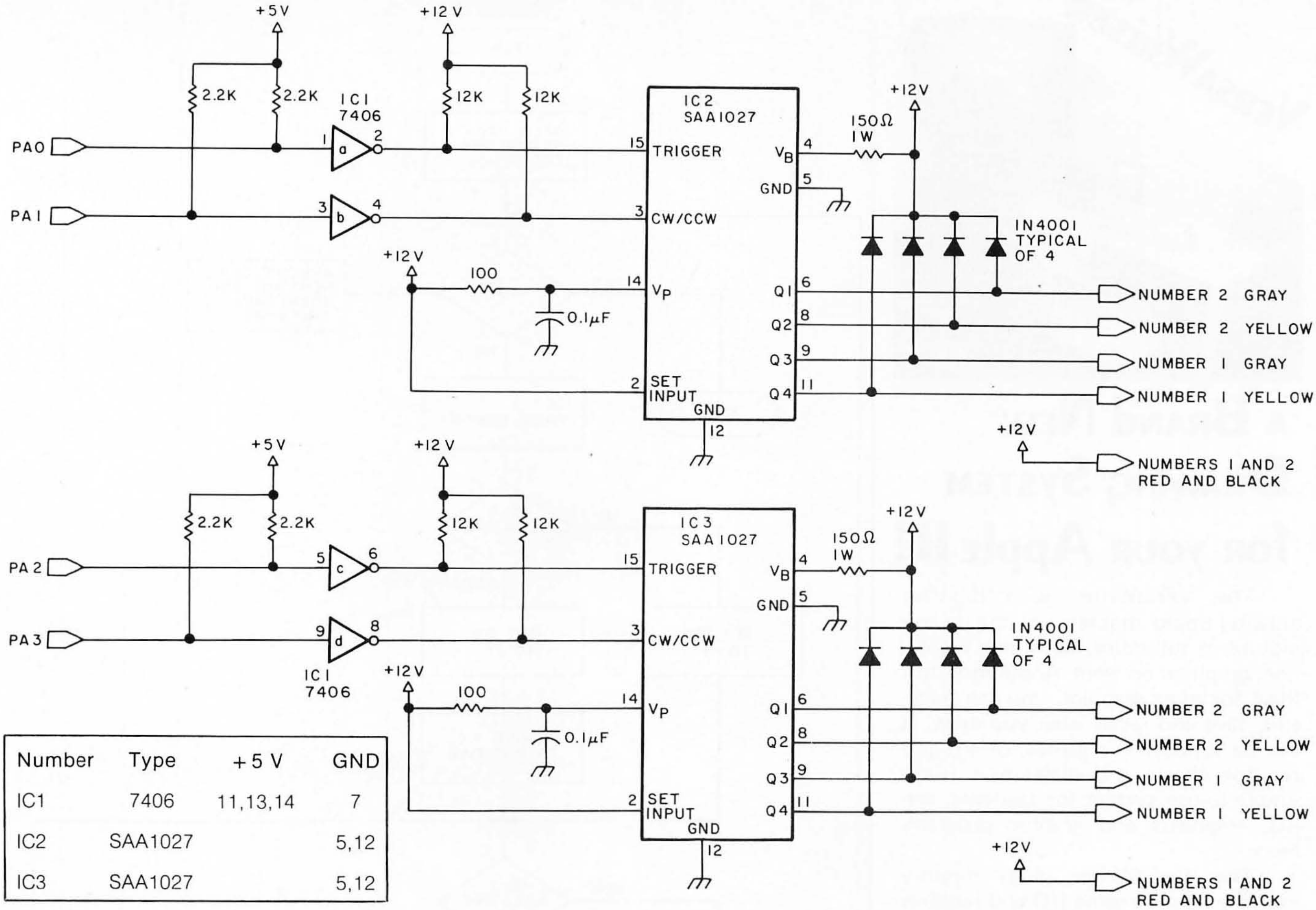
Photo 1: *The stepper motor and control assembly is mounted on the Etch-A-Sketch. The knobs have been removed to allow attachment of the driven gears to the shafts.*

Stepping Motors and Drivers

North American Philips series 82701 stepping motors were chosen for drivers, even though the Etch-A-Sketch does not require all of the torque that these motors can produce. The extra torque will come in handy if you later wish to drive something else. The motors are driven by North American Philips (or Signetics) SAA 1027 driver integrated circuits which produce the succession of pulses needed to energize the four windings on each motor. Each driver receives toggling pulses to rotate the motor shaft, while a high or low-level signal on the rotation input determines direction. A single 7406 buffer takes 5 V from the output ports and provides 12 V switching to both drivers. Figure 1 shows the circuit diagram. Each motor has an output torque of 7 ounce-inches at fifty steps per second and drives the Etch-A-Sketch through a 5 to 8 reduction gear.

Electrical Construction

A pre-etched and drilled Calectro J4-404 circuit board was used, after I sawed off the ends (to clear the stepper motors) and drilled holes for stand-offs. Two 14-pin integrated cir-



Number	Type	+5 V	GND
IC1	7406	11,13,14	7
IC2	SAA1027		5,12
IC3	SAA1027		5,12

Figure 1: *Schematic diagram of the stepper motor control and drive circuit. The integrated circuit IC2 controls the X axis; IC3 drives the motor for the Y axis.*

cuit sockets were mounted, one for the 7406 buffer and one to receive flat wire connections from the computer. For the 12 V power supply, run a two conductor, #18 cord directly to a fused (1½ A) unregulated 12 V power supply (18 V maximum peak). Number 22 wire should be used for all other connections. The last step in wiring should be to connect the stepper motors.

Mechanical Construction

The motor frame is a $\frac{3}{16}$ inch (0.476 cm) thick aluminum plate, cut to 2½ by 11 inch (6.35 by 27.94 cm) dimensions, with the stepping motors mounted on 8¼ inch (20.95 cm) centers to match the Etch-A-Sketch. You must drill clearance holes for the motor shafts (big enough to clear the twenty-tooth gears), and drill for the following items: four holes for circuit board stand-offs, two mounting holes per motor, and two holes at each end for the locating pieces that center the Etch-A-Sketch under the motor mount. Use of a drill press speeds up this work considerably. These locating pieces are $\frac{3}{8}$ by 1 by $1\frac{7}{8}$ inches (0.95 by 2.54 by 4.76 cm) long and are tapped at the top for two screws each, and at bottom for two screws which hold a ¼ by 1 by 11 inch (0.635 by 2.54 by 27.94 cm) clamp piece that keeps the motor mount and Etch-A-Sketch together. Tack or staple two pieces of $\frac{3}{16}$ inch (0.476 cm) outside diameter rubber tubing to a piece of ¾ by 1 by $4\frac{7}{8}$ inch (1.9 by 2.5 by 12.4 cm) wood to form a cushioned spacer between the motor mount and the Etch-A-Sketch. This prevents the plastic housing from cracking and spaces the assembly so that the gears line up. The driven gears (thirty-two teeth) are screw clamped to the Etch-A-Sketch control shafts after the knobs have been pulled off the device. When you slide the Etch-A-Sketch into place, move it until the gears mesh and bottom out against one another, and then slide it back about $\frac{1}{32}$ of an inch (0.08 cm). Lubricate the gears with a small amount of grease.

Programming

The first programming to be done is a routine which will rotate the stepping motors in the desired direction, one at a time. To move the Etch-A-Sketch stylus in the +Y (up) direction, output port pin PA1 should be set equal to 0 and pin PA0 is then toggled. For −Y (movement down), set PA1 to 1 and toggle PA0. Movement right and left (+X and −X) works the same way with pin PA3 setting direction. A machine language program which does this, written for the KIM-1, is given in listing 1. Figure 2 gives the flowchart, and listing 2 gives the code for a program to move the stylus along the Y axis according to data in memory, while the stylus moves one unit in the +X direction.

If a series of memory locations contain a value of 0, the stylus will move only horizontally. If a memory location contains a 1, the stylus will move

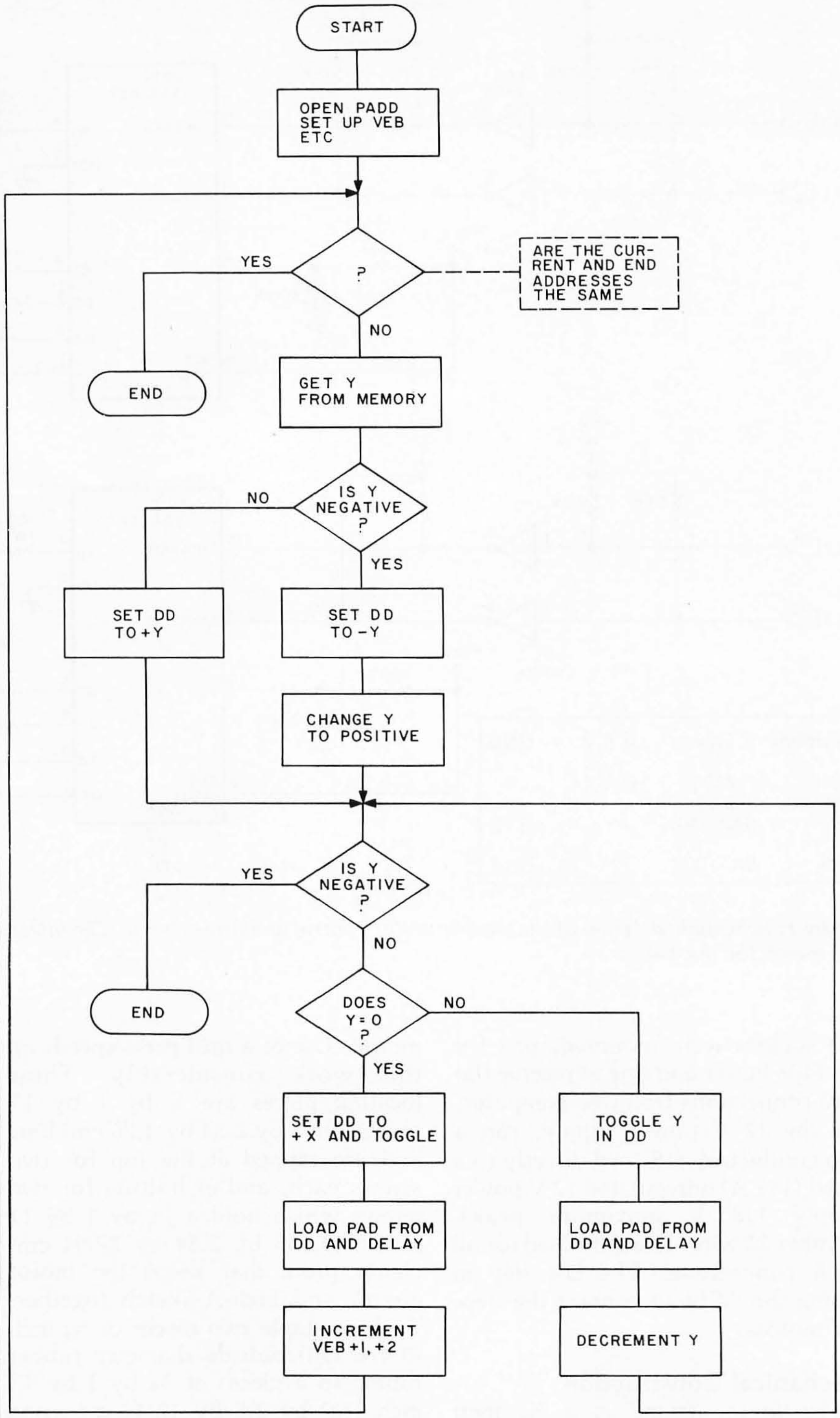


Figure 2: *Flowchart of the routine in listing 2 which moves the stylus along the Y axis according to plot data in memory while maintaining constant movement along the X axis.*

up at a 45° angle. To load the plotting data from BASIC, we set up two jumps to machine language subroutines as shown in listing 3. The first subroutine sets up a memory pointer. The second subroutine increments this pointer to load consecutive memory locations each time the BASIC program calls it. A Tiny BASIC parabola plotting program using these instructions is given as listing 4.

When you set up your programs, it is nice to avoid running off the Etch-A-Sketch screen, although no harm will result. Thus you should try not

Listing 1: *Routines written in 6502 assembler for the KIM-1 to move the Etch-A-Sketch stylus along a single axis by individually activating the stepper motors.*

Address	Hexadecimal Code	Label	Op Code Mnemonic	Operand	Commentary
3A40	A9 0F		LDAIM	$000F	SUBROUTINE TO OPEN PADD
3A42	8D 01 17		STA	PADD	
3A45	60		RTS		
3B1C	A0 FF	SPEED	LDYIM	$00FF	SUBROUTINE TO SET SPEED
3B1E	A2 20		LDXIM	$0020	
3B20	CA		DEX		
3B21	D0 FD		BNE	$3B20	DECREMENT X, LOOP IF NOT 0
3B23	88		DEY		
3B24	D0 F8		BNE	$3B1E	DECREMENT Y, LOOP IF NOT 0
3B26	A5 DE		LDAZ	$00DE	
3B28	AA		TAX		
3B29	A5 DF		LDAZ	$00DF	RESTORE X AND Y
3B2B	A8		TAY		
3B2C	60		RTS		
3A46	20 40 3A		JSR	$3A40	MOVES STYLUS IN PLUS Y
3A49	A9 01		LDAIM	$0001	DIRECTION UNTIL INTERRUPTED
3A4B	8D 00 17		STA	PAD	SET Y ROTATION OFF, Y TRIGGER ON
3A4E	20 1C 3B		JSR	SPEED	DELAY APPROPRIATELY
3A51	A9 00		LDAIM	$00	
3A53	8D 00 17		STA	PAD	SET Y TRIGGER OFF
3A56	20 1C 3B		JSR	SPEED	
3A59	4C 49 3A		JMP	$3A49	
3A66	20 40 3A		JSR	$3A40	MOVES STYLUS IN MINUS Y DIRECTION
3A69	A9 03		LDAIM	$0003	UNTIL INTERRUPTED
3A6B	8D 00 17		STA	PAD	SET Y ROTATION ON, Y TRIGGER ON
3A6E	20 1C 3B		JSR	SPEED	
3A71	A9 02		LDAIM	$0002	
3A73	8D 00 17		STA	PAD	
3A76	20 1C 3B		JSR	SPEED	
3A79	4C 69 3A		JMP	$3A69	
3A86	20 40 3A		JSR	$3A40	MOVES STYLUS IN PLUS X
3A89	A9 04		LDAIM	$0004	DIRECTION UNTIL INTERRUPTED
3A8B	8D 00 17		STA	PAD	SET X ROTATION OFF, X TRIGGER ON
3A8E	20 1C 3B		JSR	SPEED	
3A91	A9 00		LDAIM	$00	
3A93	8D 00 17		STA	PAD	
3A96	20 1C 3B		JSR	SPEED	
3A99	4C 89 3A		JMP	$3A89	
3AA6	20 40 3A		JSR	$3A40	MOVES STYLUS IN MINUS X
3AA9	A9 0C		LDAIM	$000C	DIRECTION UNTIL INTERRUPTED
3AAB	8D 00 17		STA	PAD	SET X ROTATION ON, X TRIGGER ON
3AAE	20 1C 3B		JSR	SPEED	
3AB1	A9 08		LDAIM	$0008	
3AB3	8D 00 17		STA	PAD	
3AB6	20 1C 3B		JSR	SPEED	
3AB9	4C A9 3A		JMP	$3AA9	

Listing 2: *Program written for the KIM-1 which moves the stylus along the X axis at a constant rate while movement along the Y axis is varied according to plot data stored in memory.*

Address	Hexadecimal Code	Label	Op Code Mnemonic	Operand	Commentary
3B11	A5 DD	LODPAD	LDAZ	$00DD	THIS ADDS LOADING OF THE
3B13	8D 00 17		STA	PAD	OUTPUT PORT TO THE TIMING
3B16	8A		TXA		SUBROUTINE OF LISTING 1
3B17	85 DE		STAZ	$00DE	
3B19	98		TYA		
3B1A	85 DF		STAZ	$00DF	
3B30	A9 0F		LDAIM	$000F	THIS IS THE PROGRAM SHOWN
3B32	8D 01 17		STA	PADD	IN FIGURE 2. ZERO PAGE
3B35	AD F5 17		LDA	SAL	LOCATIONS CC THROUGH CF ARE
3B38	85 CC		STAZ	CURADL	VECTOR EB. LOCATION DD
3B3A	AD F6 17		LDA	SAHI	IS STORAGE FOR PORT A DATA
3B3D	85 CD		STAZ	CURADH	
3B3F	A9 AD		LDAIM	$00AD	
3B41	85 CB		STAZ	GETY	
3B43	A9 A8		LDAIM	$00A8	
3B45	85 CE		STAZ	$00CE	
3B47	A9 60		LDAIM	$0060	
3B49	85 CF		STAZ	$00CF	
3B4B	A5 CC	COMEND	LDAZ	CURADL	COMPARE VEB + 1, VEB + 2 WITH
3B4D	CD F7 17		CMP	ENDALO	END ADDRESS

Listing 2 continued on page 206

Listing 2 continued:

3B50	A5 CD		LDAZ	CURADH	
3B52	ED F8 17		SBC	ENDAHI	
3B55	B0 43		BCS	END	TO END IF ADDRESSES MATCH
3B57	20 CB 00		JSR	GETY	
3B5A	10 0E	YPLUS	BPL	SETPLS	Y POSITIVE
3B5C	A9 02		LDAIM	$0002	
3B5E	05 DD		ORAZ	$00DD	SET ROTATION IN DD FOR −Y
3B60	85 DD		STAZ	$00DD	
3B62	98	MITOPL	TYA		CHANGE −Y TO +Y
3B63	49 FF		EORIM	$00FF	
3B65	A8		TAY		
3B66	C8		INY		
3B67	4C 70 3B		JMP	YMINUS	JUMP PAST SET PLUS ROTATION
3B6A	A9 FD	SET PLS	LDAIM	$00FD	SET Y ROTATION FOR PLUS
3B6C	25 DD		ANDZ	$00DD	
3B6E	85 DD		STAZ	$00DD	
3B70	98	YMINUS	TYA		Y IS STILL MINUS, END ROUTINE
3B71	30 27		BMI	END	
3B73	F0 0D		BEQ	$3B82	Y =0, BRANCH
3B75	A9 01	TOGY	LDAIM	$0001	TOGGLE Y IN DD
3B77	45 DD		EORZ	$00DD	
3B79	85 DD		STAZ	$00DD	
3B7B	20 11 3B		JSR	LODPAD	LOAD PAD FROM DD AND DELAY
3B7E	88		DEY		DECREMENT Y
3B7F	4C 70 3B		JMP	YMINUS	JUMP BACK TO SECOND "IS Y MINUS"
3B82	A9 07		LDAIM	$0007	SET DD TO PLUS X
3B84	25 DD		ANDZ	$00DD	
3B86	85 DD		STAZ	$00DD	
3B88	A9 04	TOGX	LDAIM	$0004	TOGGLE X IN DD
3B8A	45 DD		EORZ	$00DD	
3B8C	85 DD		STAZ	$00DD	
3B8E	20 11 3B		JSR	LODPAD	LOAD PAD FROM DD AND DELAY
3B91	E6 CC		INCZ	CURADL	INCREMENT VEB+1
3B93	D0 02		BNE	$3B97	
3B95	E6 CD		INCZ	CURADH	INCREMENT VEB+2
3B97	4C 4B 3B		JMP	COMEND	REPEAT
3B9A	00	END	BRK		END

Listing 3: *Machine language subroutines which are called from the Tiny BASIC program of listing 4. The first routine sets up a memory pointer. The second routine increments the pointer to load consecutive memory locations each time the BASIC program calls it.*

Address	Hexadecimal Code	Label	Op Code Mnemonic	Operand	Commentary
1780	A9 8D		LDAIM	$008D	SET UP MEMORY POINTER WITH
1782	85 DA		STAZ	$00DA	MEMORY STARTING ADDRESS
1784	A9 00		LDAIM	$00	SET LOW STARTING ADDRESS
1786	85 DB		STAZ	SUBPAD	
1788	A9 02		LDAIM	$0002	SET HIGH STARTING ADDRESS
178A	85 DC		STAZ	$00DC	STARTING ADDRESS DEFAULT
178C	A9 60		LDAIM	$0060	IS 0200.
178E	85 DD		STAZ	$00DD	
1790	60		RTS		RETURN
1791	20 DA 00		JSR	$00DA	LOAD MEMORY WITH CONTENTS
1794	E6 DB		INCZ	SUBPAD	OF ACCUMULATOR
1796	D0 02		BNE	$179A	
1798	E6 DC		INCZ	$00DC	INCREMENT MEMORY POINTER
179A	60		RTS		RETURN

Listing 4: *Program written for the KIM-1 in Tiny BASIC to plot a parabola using the machine language routines of listing 3.*

```
100    LET N = USR (6016)
105    REM THIS IS 1780 HEXADECIMAL
110    LET C = -120*120/10
120    LET A = -119
130    LET B=A*A/10
140    LET D=B-C
150    LET C=B
160    IF D= -2 THEN LET D= -3
190    IF D=2 THEN LET D=3
200    LET D=D/3
210    LET N=USR(6033,0,D)
215    REM THIS EQUALS 1791 HEXADECIMAL
216    REM SUBROUTINE IS ENTERED WITH D IN ACCUMULATOR
220    LET A=A+1
230    IF A>120 GOTO 250
240    GOTO 130
250    END
```

Parts List

2 gears: Sterling S1268ZS20AP1 (32 pitch, 32 teeth) or equivalent
2 hubs: Sterling E62-4 (3/16 inch bore for above) or equivalent
2 gears: Sterling S1086ZH2920P1 (32 pitch, 20 teeth, ¼ inch bore) or equivalent
2 stepper motors: North American Philips Controls Corp K82701P2
2 stepper motor driver integrated circuits: Signetics SAA1027
1 circuit board: Calectro J4-404
Miscellaneous sheet aluminum and screws, wood block, and rubber tubing.

A limited quantity of kits of the above items (ready to assemble with no cutting or drilling necessary) are available from the author for $109 postpaid, plus tax for Illinois residents.

The following items are stocked by most electronic distributors:
2 16-pin soldertail integrated circuit sockets
2 14-pin soldertail integrated circuit sockets
1 type 7406 integrated circuit hex inverting driver
4 2.2K ohm ¼ W resistors
4 12K ohm ¼ W resistors
2 100 ohm ½ W resistors
2 150 ohm 1 W resistors
2 0.1 μF 36 V capacitors
8 1N4001 rectifier diodes
1 0.001 μF 16 V capacitor

to use more than 790 (decimal) memory locations in the program of listing 3. The total of all negative or positive numbers in the parabola plotting program of listing 4 should be less than decimal 558.

The stepper drivers generate some electrical noise. I have no trouble with BASIC crashing, provided that the 12 V supply is off. For cassette recording, both 12 V and 5 V supplies should be off. For playback, both supplies can be on. Before disconnecting the I/O ports from the Etch-A-Sketch, push reset (RS) to switch the ports to their high impedance position. This eliminates the possibility of destroying the 7406 buffer device.

Once you have loaded the program into memory and have stored it on a cassette, plug the connections from the 7406 buffer into your computer and turn on the 12 V supply (with the 1½ A fuse in place). Using the monitor, execute the appropriate subroutines from listing 1 to move the stylus to the desired origin (typically upper left). Starting execution at hexadecimal location 3B30 will plot whatever data is contained in memory.

With experience in programming, you can set up a grid against which plotting can be done. The fine line produced by the Etch-A-Sketch makes measuring easy. Two advantages of the Etch-A-Sketch are that you don't use any memory preserving information on the screen, and the device is completely nonvolatile. Begin a plot today, shut down your system before finishing, and weeks later you can come back and continue the plot. You will also experience the satisfaction of watching your computer move things in the real world, rather than manipulate shadows on a television screen. ■

BYTE's Bits

Personal Computers for the Handicapped

The Applied Physics Laboratory of Johns Hopkins University is the location of a project being organized by Paul L Hazan. This project is a program for the application of personal computers to the problems of people with various physical handicaps.

Various applications include simple computer-controlled communications aids for quadriplegics, interfaces between computers that allow hearing-impaired individuals to communicate via telephone, and other very inexpensive applications of off-the-shelf hardware. A design contest with substantial prizes is being considered.

Those interested in more details may contact Paul L Hazan, Assistant to the Director for Advanced Computer Technology, Johns Hopkins University, Applied Physics Laboratory, Johns Hopkins Rd, Laurel MD 20810.■

BYTE's Bugs

Chess Moves Rechecked

Thanks to John Gropper for pointing out an error in "Alpha-Beta Pruning," by W D Maurer (November 1979 BYTE, page 84). Figure 1 gives white's second move as Q-N7. The correct move is Q-N8. The move is shown correctly in figure 2.■

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ISBN 0-07-024120-1
Authors: Robert D. Grappel & Jack E. Hemenway
Pages: 72 **Price:** $8.00

BASEX, a new compact, compiled language for microcomputers, has many of the best features of BASIC and the 8080 assembly language — and it can be run on any of the 8080 style microprocessors: 8080, Z-80, or 8085. Subroutines in the BASEX operating system typically execute programs up to five times faster than equivalent programs in a BASIC interpreter — while requiring only about half the memory space. The author, Paul Warme, has also included a BASEX loader program which is capable of relocating programs anywhere in memory. This is a PAPERBYTE® book.
ISBN 0-07-068290-9
Author: Paul Warme
Pages: 88 **Price:** $8.00

TRACER: A 6800 DEBUGGING PROGRAM includes a reprint of "Jack and the Machine Debug" (from the December 1977 issue of BYTE magazine), TRACER program notes, complete assembly and source listing in 6800 assembly language, object program listing, and machine readable PAPERBYTE® bar codes of the object code.
ISBN 0-07-024121-X
Authors: Robert D. Grappel & Jack E. Hemenway
Pages: 24 **Price:** $6.00

MONDEB: AN ADVANCED M6800 MONITOR-DEBUGGER features ease of use and minimum memory requirements while retaining maximum versatility. The result is an extremely versatile program. The size of the entire MONDEB is less then 3K. This is a PAPERBYTE® book.
ISBN 0-07-049556-4
Author: Don Peters
Pages: 88 **Price:** $5.00

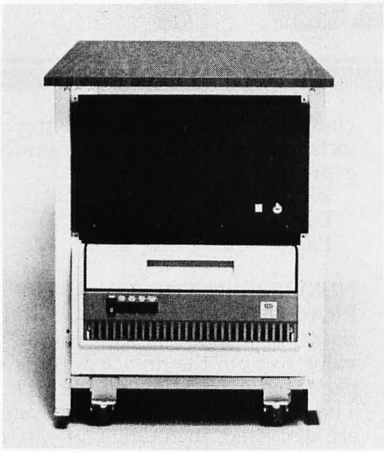
BAR CODE LOADER contains the general bar code loader algorithm description in flowchart form plus detailed assemblies of program code for 6800, 6502, and 8080 processors. Individuals with computers based on these processors can use the software directly. Individuals with other processors can use the provided functional specifications and detail examples to create equivalent programs. This is a PAPERBYTE® book.
ISBN 0-07-008856-X
Author: Ken Budnick
Pages: 32
Price: $2.00

K2FDOS: A FLOPPY DISK OPERATING SYSTEM FOR THE 8080. K2FDOS is a complete software package and includes all the information and specific routines necessary to bootstrap and run a powerful floppy disk operating system on an 8080-based microcomputer. This small (4K), but powerful, system includes many of the file handling features of large operating systems. It comes complete with source code listings in the hexadecimal format, and machine readable (PAPERBYTE®) bar code format listings for individual K2FDOS programs.
ISBN 0-07-069206-8
Author: Kenneth B. Welles
Pages: 192
Price: $20.00

What's New?

PERIPHERALS

90 M Byte Disk Subsystem



The model AM 410 90 M byte (formatted) disk subsystem is based on the CDC Phoenix drive. The unit consists of 75 bytes of fixed disk capacity combined with 15 M bytes of removable cartridge. The controller is interrupt driven and operates on full 512-byte sector data transfers. The AM 410 has an average access time of 30 milliseconds and provides full cyclic redundancy check (CRC) and sentinel bit error checking capabilities. Up to four drives can be connected to one controller for a total storage capacity of 360 M bytes of data. The AM 410 is designed to work with Alpha Micro's AMOS operating system and other operating systems on either the 8- or the 16-bit S-100 bus. The self-contained unit is available from Alpha Micro, 17881 Sky Park N, Irvine CA 92714, for under $15,000.

Circle 451 on inquiry card.

Printers and Plotters for the Apple II, PET, TRS-80

Axiom Corp, 5932 San Fernando Rd, Glendale CA 91202, has introduced the EX-801 and EX-820 series printers and plotters for the Apple II, PET, and TRS-80. Each printer can be plugged into the different microcomputers without any special user adaptation.

The EX-801 features the full 96-character ASCII set, 80 characters per line, 80 columns, and full user control of individual dots in graphics mode.

The EX-820 includes all the features of the EX-801 plus the capability of being a full plotter that can generate schematics, musical scores, charts and other displays. The EX-820 can print any graphics image with up to 128 dots per inch resolution.

The price for the EX-801 is $535.

Circle 452 on inquiry card.

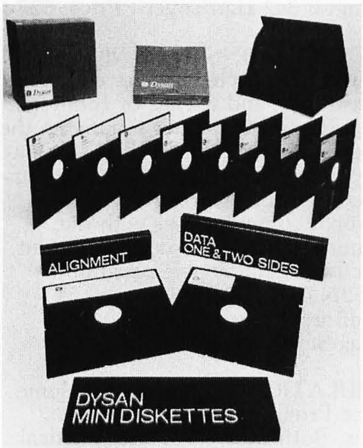
The Sorcerer's Voice

The model SV-100 is a self-contained device that generates tones, musical notes, and sound effects. The unit plugs into the parallel output port of the Sorcerer and features a built-in speaker. The SV-100 utilizes twenty-one tones including twelve musical notes. A cassette includes an INTRO for the SV-100; SDEFT, a sound effects program; MUSIC, a real-time music composition program; and HORSE, a horse race game with sound effects.

The SV-100 is available from Indiana Digital Corp, POB 3755, South Bend IN 46619, for $49.95.

Circle 453 on inquiry card.

100% Error Free Floppy Disks



Error free single- and double-sided 5-inch floppy disks in 35- or 40-track versions are available from Dysan Corp, 5440 Patrick Henry Dr, Santa Clara CA 95050. They are available in hard- or soft-sectored versions.

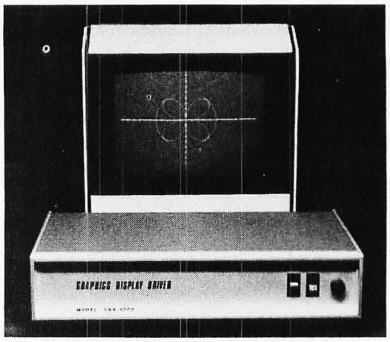
Circle 454 on inquiry card.

Standard Letter-Quality, Wide Carriage Printer

The CPT Rotary V is an up to 40 character per second (cps) serial printer with letter-quality printout, a metal daisy print wheel, and the printer can be used with the CPT 6000 and 8000 word processing systems. Featured are an adjustable platen for multiple part forms, ribbon lift for position accuracy, and bidirectional paper feed for forms fill-in applications. The Rotary V is priced at $4000 and is available from CPT Corp, 1001 2nd St S, Hopkins MN 55343.

Circle 455 on inquiry card.

Universal Graphics Display Peripheral



The G-Box is a peripheral device which can be used with any computer to add high-density graphics. The video image output is a matrix of 512 by 240 dots with an expansion capability. Connection to the computer is through an RS-232 serial link. The G-Box accepts standard ASCII codes and it does not require assembly language routines. It can be controlled from BASIC and other languages. Interfaces for joysticks, serial and parallel ports, a light pen interface, and other options are built into the unit. The G-Box can be adapted to work on the TRS-80, Heath, Commodore, North Star, and other microcomputers. Prices range from approximately $350 for the primary version (without cabinet), up to over $2000 for terminal units with full options. Contact Objective Design Inc, POB 20325, Tallahassee FL 32304.

Circle 456 on inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first in first out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

What's New?

SOFTWARE and PERIPHERALS

IBM to CP/M or CP/M to IBM Transfer Utility Program

The IBM2CPM program uses an IBM or equivalent mainframe to develop systems for microcomputers using cross-compilers and assemblers. The resulting source programs are transferred to the microcomputer via a standard 8-inch floppy disk. This system enables a microcomputer to act as a data entry system for a large mainframe. The program features interactive operation that allows users to specify which files to copy, the ability to display the directory on an IBM standard interchange floppy disk, and more. IBM2CPM is available from Precision Computer Systems Inc, 1737 N First St, San Jose CA 95112 for $95.

Circle 457 on inquiry card.

Bus(iness) 1

Designed for SwTPC 6800 and PET systems, this package contains thirty programs, including payroll, cash flow, profit and loss accounting, stock control, invoices, sales ledger, updating address files, and more. The package can run up to four companies, eight bank accounts, fifty agents, 999 customers or suppliers, 1000 stock items and two-hundred employees, depending on disk storage. The program can run in 20 K bytes of memory and has been adapted to the 6502 processor. It costs $275 plus value added tax (VAT). For more information, contact G W Computers Ltd, 89 Bedford Court Mansions, Bedford Ave, London WC1 ENGLAND.

Circle 458 on inquiry card.

Software Protection for S-100 Bus Systems

International Product Development Inc, 1708 Stierlin Rd, Mountain View CA 94043, has developed the LW100 board that operates with standard software, as well as protected software that can be copied for a user's computer. Each LW100 board contains a key that is different from all other boards. The protected software has a key lock programmed to work with only one computer. Manufacturers and software houses that wish to protect their software would supply the customer with a LW100 board and protected software. Future sales to that cutomer require only the protected software that works with the customer's keyed computer. The cost for the board is $139.

Circle 459 on inquiry card.

WIZRD Multitasking Disk Operating System

Wintek's system includes true device-independent (virtual) input/output (I/O); HEAP memory management for efficient memory allocation for I/O buffers; and command indirection, which allows commands to be read from files with no operator intervention. It is helpful for systems used by untrained operators. WIZRD is included with Wintek's 48 K, dual-drive SPRINT 68 microcomputer for $3995, or alone for $495. For information, contact Wintek Corp, 1801 South St, Lafayette IN 47904.

Circle 460 on inquiry card.

Word Processor for Apple II and Apple II Plus Systems

Super-Text is a multiple paging system that allows users to view two text screens simultaneously, keep notes or instructions on one text screen and edit on the other. It features full floating cursor and cursor control; insertion and deletion of characters, words or lines; tabbing; justification; full scrolling; movement to the last change made in the text; global search and replace; block operations; and advanced file handling and print controls. The system runs in 48 K bytes of memory and costs $99.95. It is available from Muse Co, 7112 Darlington Dr, Baltimore MD 21234.

Circle 461 on inquiry card.

Text Formatter for UCSD Pascal Systems

Using the Moonshadow Text Formatter, documents produced with the screen editor are post-processed to provide underlining, automatic pagination, and other essential text-processing functions. It takes standard Pascal text files, operates on them, and sends fully formatted text output to the console display, a printer, or a disk file. Moonshadow Text Formatter provides a full range of formatting functions, plus advanced features such as combining of files into one document, variables in text (for form letters), and output character translation (for printers using nonstandard character sets).

The program is written in UCSD Pascal and works on systems using either North Star 5-inch floppy disks or IBM format 8-inch floppy disks. It is available from Merrimack Systems, POB 5218, Redwood City CA 94063, for $99.

Circle 462 on inquiry card.

APL for the 8080, 8085, and Z80

Softronics APL has most of the functions and operators of full APL, including n-dimensional inner and outer product, reduction, compression, general transpose, reversal, take, drop, execute and format, system functions and variables, and system commands. It runs under the CP/M operating system, residing in 30 K bytes of memory. In addition to standard ASCII mnemonic representations, it supports typewriter and bit-pairing ASCII-APL character sets. The shared variable mechanism allows CP/M disk input and output. Softronics APL comes with an optional driver program for video display with programmable character generator. It is priced at $350 on disk, with a user's manual. For more information, contact Softronics, 36 Homestead Ln, Roosevelt NJ 08555.

Double-Sided Dual Disk Drive

The Micro Squared M-250 unit is capable of single or double density and consists of two double-sided drives, a power supply, cable, and chassis. It has 140 tracks, with a capacity of 358 K bytes of memory. The double-density feature allows 875 K bytes of memory storage. The unit also features a write protect sensor, time erase timing circuits internal to the disk drive, and has a sensor that stops the spindle drive motor rotation when no disk is installed. The unit costs $1195 and is available from Micro Squared Inc, Suite 5B, 7131 Owensmouth Ave, Canoga Park CA 91303.

Circle 463 on inquiry card.

Pertec Introduces 8-Inch, 20 M Byte Winchester Drive

This new drive will use a limited motion, 50 ms average access rotary positioner. The Mini-Wini can perform diagnostic routines without the help of the central processing unit by creating a bidirectional bus interface using a 6801 microprocessor. The Mini-Wini has the same physical dimensions, mounting scheme and voltage requirements as floppy disk drives, but offers more storage space than floppy disks. The price is $3000 and is available from Pertec Computer Corp, 9600 Irondale, Chatsworth CA 91311.

Circle 464 on inquiry card.

What's New?

SOFTWARE

North Star List Processor

HELPB5 is a collection of subroutines which use dynamic memory assignment to perform list processing. The user can create a sequential set of array elements which describe objects. By filing sets on and removing sets from various lists, complex processes can be simulated. Available subroutines include Create, Destroy, File First, File Last, File Ranked—which places an entity on a sorted list based on the value of a selected array element—Remove First, Remove Last, and Remove. Four debugging routines allow the user to print all the objects on a list, determine if a particular object is on a specified list, if an array element has a specified value, and print the array elements for a particular entity.

HELPB5 is written in North Star BASIC and needs a minimum of 32 K bytes of programmable memory. The price is $48, including a user's manual and sample simulation program. Contact American Planning Corp, 4600 Duke St, Suite 425, Alexandria VA 22304.

Circle 465 on inquiry card.

NEVADA COBOL for Microcomputers

NEVADA COBOL translates source language programs into machine language on 8080, Z80 and 8085 microprocessors. Designed for small businesses using microcomputers, it features random access file support; sequential files, both fixed and variable length; debugging capability; copy statement; character string, 16-bit binary and packed decimal (COMP-3); 18-bit accuracy; hexadecimal non-numeric literals; and an interactive ACCEPT/DISPLAY. The compiler, which is a subset of ANSI-74, generates programs at a rate up to 650 lines per minute on an 8080-based system. Operating under Processor Technology's operating system (PTDOS), the compiler requires a minimum of 32 K bytes of programmable memory. *The NEVADA COBOL Programmers Reference Manual* is available for $25 and the Diskette is $275, from Ellis Computing, 1480 17th Ave, San Francisco CA 94122.

Circle 466 on inquiry card.

Library Cross-Reference for Floppy Disks

The CATALOG system provides a means to index up to 200 single- or double-density 5-inch floppy disks. Using the alphabetical lists of files produced by CATALOG, any program or data file can be located in a few seconds. The name, extension, size, date and disk number for each file is listed in each of three reports. These reports are organized by the date within extension within name, extension within name within disk number, and date within name within extension. A list of disks is provided after each use of the CATALOG program. The program runs on 8080 or Z80 microprocessors with 48 K bytes of memory, floppy disk, video display and printer. The program requires CP/M with Microsoft MBASIC or MITS/Pertec Disk Extended BASIC. The SORT System is required for use of CATALOG. The CATALOG System is priced at $95 and is available from the Software Store Ltd, 706 Chippewa Sq, Marquette MI 49855.

Circle 467 on inquiry card.

6809 Systems Software

Technical Systems Consultants Inc, POB 2574, W Lafayette IN 47906, has developed software which includes a 6809 version of the popular FLEX disk operating system, a text editor, a resident assembler, BASIC interpreter, and an assembly language debug package. Most software written for 6800 FLEX can be reassembled for 6809 by changing any equates into FLEX to the proper addresses. FLEX features dynamic file allocation, random and sequential files, printer spooling, batch job type program entry, automatic space compression, user start-up facility, and English error messages. The resident 6809 assembler accepts 6809, 6800, and 6801 mnemonics so that existing software can be immediately reassembled to produce 6809 object code.

FLEX is available for the SwTPC disk systems on a 5- or 8-inch floppy disk. The other software is available on a standard 5- or 8-inch FLEX disk which may be used on any soft-sectored 6809 FLEX disk system. Cassette versions are available for all but FLEX. Including the text editor and assembler, the FLEX package is $90. The BASIC interpreter is $65, and the debug package is $75.

Circle 468 on inquiry card.

Six Software Programs for Apple Users

These six programs from Williamsville Publishing require an Apple II with 32 K bytes of programmable memory, one disk drive, Disk II, Applesoft II in read-only memory (ROM) on a firmware card. The programs include Book Library; Record Library; Malum II...Imperial Roman Programmable Computer By Command of Caesar, which takes the Latin equivalent of BASIC commands and uses Roman numerals for numeric input and output; Graphics Game; Checkbook Program; and Page Processor.

Individual disks sell for $19.95 from Williamsville Publishing Co, POB 250, Fredonia NY 14063.

Circle 469 on inquiry card.

Software for Radio and Television Stations

Solar Computer Systems Corp, 2360 43rd Ave E, Suite 308, Seattle WA 98112, has a series of software programs designed to run on Smoke Signal Broadcasting's Chieftan Systems that are of interest to radio and television stations. Available programs include audience measurement, attitude research, music research, lifestyle surveys, ARBITRON analyses and more. Information is available upon request.

Circle 470 on inquiry card.

Math Program Performs Symbolic Operations for Algebra, Trigonometry, and Calculus

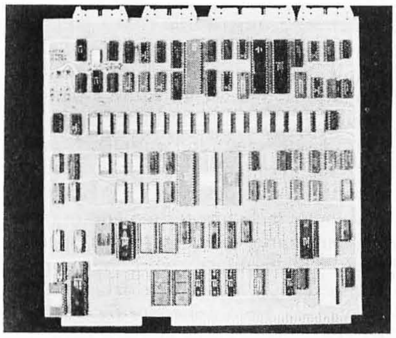
This symbolic mathematics system enables users to solve polynomial multiplications, symbolic differentiations and integrations, simplification of trigonometric expressions, and exact solutions of nonlinear equations. The muMATH-79 programs run on 8080, 8085, and Z80 systems using TRSDOS, standard CP/M, or upward compatible operating systems such as Cromemco CDOS, or IMSAI IMDOS. The program is useful for engineers and scientists in checking or deriving lengthy analytical data. It is also useful for artificial intelligence applications as well as for students and teachers in math education. The price for the package is $190. For more information, contact The Soft Warehouse, POB 11174, Honolulu HI 96828.

Circle 471 on inquiry card.

What's New?

SYSTEMS

Single Board Computer Supports Pascal



DOSC Inc, 500 Fifth Ave, New York NY 10033, has announced its TCB-85 single board microcomputer capable of supporting CP/M and Pascal. The 64 K board is compatible with Intel's Multibus and features a dual-density floppy disk controller that supports up to four disk drives or two double-sided disks, video display controller with up to 80 characters by 25 lines, RS-232 serial input/output (I/O) port, parallel printer interface, scanned keyboard interface, vectored interrupts, and three timers.

The price is $1500 per unit.

Circle 472 on inquiry card.

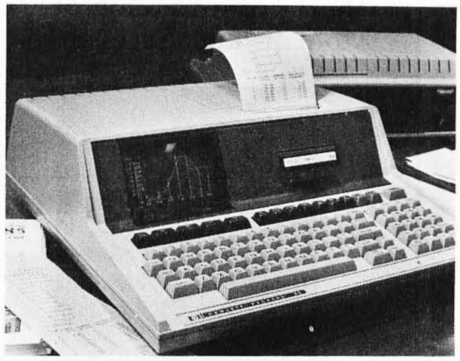
Hewlett-Packard Introduces Personal Computer for Professionals

The HP-85 is a complete computer system designed for use in business and industry by engineers, scientists, accountants, and investment analysts. It can also be used in the home by hobbyists and as an instructional computer in secondary schools, colleges, and universities.

The system features a video display, thermal printer, tape cartridge, and graphics capability in a package the size of a typewriter. It is equipped with four input/output (I/O) ports to allow the user to expand the system to include plotters, printers, disk drives, and other peripherals that are already on the market.

The HP-85 comes with 16 K bytes of programmable memory and can be expanded to 32 K by plugging an optional memory module into one of the ports on the back of the machine. The graphics display is useful to engineers for plotting functions and for test analysis, and to business persons to plot statistics. The display on the screen can be easily printed out on the built-in printer.

The system has a 5-inch, high-resolution, black and white video display with 16 lines of display and 32 characters per line. The thermal printer, which operates in both alphanumeric and graphics modes, prints two 32-character lines per second. The HP-85 tape drive uses HP Data Cartridges, which have a capacity of 200 K bytes, and feature a tape directory that enables the system to automatically find exact tape locations of recorded programs and data.



The HP-85 measures 41 by 46 by 15 cm (16 by 18 by 6 inches), and weighs 9.06 kg (under 20 pounds). It comes with a user's manual and a standard application software package that contains 15 programs. The price of the HP-85 is $3250. For more information, contact Inquiries Manager, Hewlett-Packard Co, 1507 Page Mill Rd, Palo Alto CA 94304.

Circle 474 on inquiry card.

Versatile Business Manager System

This system includes a Versatile 4 Dual Drive computer, a Texas Instruments 810 RO Tractor Feed Printer, application software for business, and a movable table. The business software includes a General Ledger, Accounts Payable and Receivable, Inventory, Personnel/Payroll, and Labor Job Cost Analysis. The system is priced at under $8500 and is available from CDS Inc, Building 3, Drummond Plaza, Newark DE 19711.

Circle 473 on inquiry card.

8086 and 8088-Based Microcomputers

Microbyte, 2499 Cerritos Ave, Signal Hill CA 90806, has introduced two 16-bit 8086 and 8088 microprocessor-based computers with real-time clock, priority vectored interrupts, four port serial input and output (I/O) board that supports four terminals, 32 K bytes of programmable memory, dual-density floppy disk controller that supports up to four drives with direct memory address (DMA) data transfer, video display and keyboard, 19-slot backplane, and an interrupt switch-on from console to allow re-boot of the system without register destruction. The systems use Microbyte DOS86 batch operating system software and also feature 4 K bytes of programmable memory on-board, 24 operand addressing modes, three programmable timers, and more. The approximate prices for the 8086 and 8088 are $4000 and $3900, respectively.

Circle 475 on inquiry card.

Compucolor II System

Compucolor Corp, POB 569, Norcross GA 30071, has developed three models of the Compucolor II. Model 3 has 8 K bytes of programmable memory, the Model 4 has 16 K bytes, and the Model 5 provides 32 K bytes of memory. The Compucolor II uses an 8080A microprocessor and includes 16 K bytes of read-only memory. One RS-232C serial port is provided for a printer or modem. The Compucolor II features a keyboard that is separate from the processor and video display unit. The video terminal has erase-line and erase-page commands; two character sizes; fifteen plot modes; local, full, and half duplex modes; full cursor control; and other functions. The system uses Disk BASIC 8001 with an interpreter in read-only memory. Twenty-nine statement types, three command types, nineteen mathematical functions, and nine string functions are included.

One 5-inch floppy disk is built into the main unit. The capacity for each side of a 5-inch disk is 51.2 K bytes.

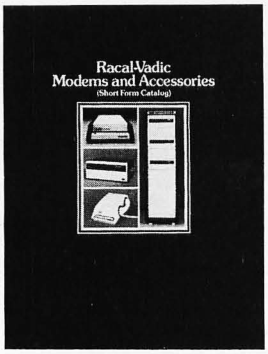
The video display features eight colors with 32 lines and 64 characters per line. The usable screen area is 23 cm (9 inches) wide by 17 cm (6.75 inches) high. Compucolor has developed software for the system including games, small business applications, home finance, and other programs. The prices for the three models are $1495, $1695, and $1995.

Circle 476 on inquiry card.

What's New?

PUBLICATIONS

Short Form Catalog of Modems and Accessories



This six-page catalog contains Racal-Vadic's 1200 bits per second (bps) full-duplex acoustic coupler; the "50" series of direct connect modems; and the VA3467 triple modem which emulates a Racal-Vadic VA3400 series modem, a Bell 212A, or a Bell 103. Other products include Bell-compatible 300 bps, 1200 bps half-duplex, and 2400 bps modems; CCITT compatible modems; automatic dialers; and a Multiline Automatic Calling System, which can handle up to 60 modems for each dialing port. For further information, contact Racal-Vadic, 222 Caspian Dr, Sunnyvale CA 94086.

Circle 477 on inquiry card.

Introduction to VLSI Systems

Introduction to VLSI Systems, by Carver Mead and Lynn Conway, deals with the theory and practice of designing, fabrication, and implementing of silicon chips, and it provides detailed coverage of the underlying physics to complete very large-scale integration (VLSI) digital computer systems. *Introduction to VLSI Systems* is suitable as a textbook and reference book for graduate and undergraduate courses.

The book is available from Addison-Wesley Publishing Co, Reading MA 01867, for $25.95.

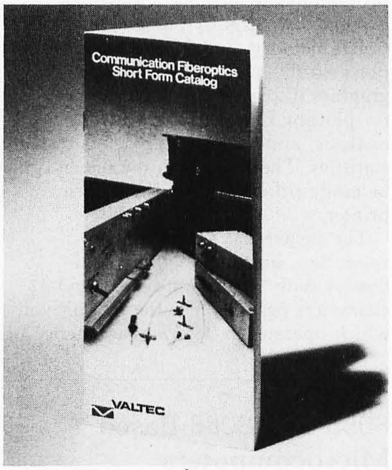
Circle 478 on inquiry card.

Sharp APL Reference Manual

This text is complete with illustrations and examples, and it discusses the features of Sharp APL in terms understandable by beginners and professional programmers alike. Some of the topics reviewed are syntax of APL, event trapping, primitive functions and operations, structure of data, shared variables, report formatting, batch APL, and line editing in Sharp APL. The manual is available for $18 from I P Sharp Associates Ltd, 145 King St W, Toronto, Ontario M5H 1J8, CANADA.

Circle 479 on inquiry card.

Communication Fiber-optics Short Form Catalog



Valtec Corp's catalog, which includes their optical fibers and cables, fiberoptic modems and interfaces, and baseband video links, covers every application from computer terminal connections to long-haul telephone and CATV trunking.

To obtain a copy of the catalog, write Valtec Corp, Communication Fiber-optics, 99 Hartwell St, West Boylston MA 01583.

Circle 480 on inquiry card.

1979 Mapping Collection from Harvard Library of Computer Graphics

This six volume collection has been structured to give an organization every kind of information it may need about computer mapping. The collection features works on management's use of maps; natural resource and environmental applications; urban, regional, and state applications; computer mapping in education; mapping software and cartographic data bases; thematic map design; and sections on cadastral systems and use of satellite derived data. The cost is $45 for the first volume, and $30 for each additional selection. The complete six volume set is $150. Contact the Laboratory for Computer Graphics, Harvard University, 48 Quincy St, Cambridge MA 02138.

Circle 481 on inquiry card.

Publication for the Ohio Scientific Challenger 1P

Getting Started With Your Challenger 1P introduces the fundamentals of C1P BASIC and explains its characteristics, limitations, and useful features. This document discusses calculator and program mode, input and output, data representation, and program storage on cassette. It also describes C1P control and logic, including testing and branching, subroutine use, and logical operations. This beginner's workbook contains exercises and sample programs. It is available from dealers or by writing to TIS, POB 921, Los Alamos NM 87544. The price is $5.95 plus $1 for postage and handling.

Circle 482 on inquiry card.

Microprocessor User's Guide

The Microprocessor User's Guide contains articles written by engineers for other engineers and corporate managers with a production-oriented, problem solving approach in mind. The 78-page booklet focuses on designing with microprocessors; engineering design approach to microprocessors; microprocessor architecture; analysis of 6800, 8080/8085 and Z80 architectures; and analysis of single-chip microprocessors. Pro-Log's STD BUS, a bus structure for 8-bit microprocessors, is examined in detail.

The guide is available at no charge from Pro-Log Corp, 2411 Garden Rd, Monterey CA 93940.

Circle 483 on inquiry card.

Using a Programmable Calculator Instead of a Central Computer

Providing techniques for using calculators in the HP-67/97 or TI-59 families, the *Handbook of Electronic Design and Analysis Procedures Using Programmable Calculators* offers programs and programming techniques for solving problems in network analysis, active and passive filter design, high frequency amplifier design, and engineering mathematics. Documentation including flowcharts, algorithms, sample problems, tips, and references clarify many aspects of problem solution. The book is available for $26.50, from Van Nostrand Reinhold Electrical/Computer Science and Engineering Series, 135 W 50th St, New York NY 10020.

Circle 484 on inquiry card.

What's New?

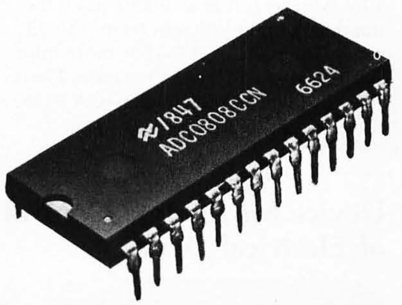
MISCELLANEOUS

GPIB Controller Implements IEEE 488 Bus and RS-232 Standard



The Model 609 GPIB Controller can be used in place of programmable calculators, microcomputers, or as intelligence for a data collector logger system. Programs in BASIC enter in 4 K bytes of programmable memory, then are transferred to an internal programmable read-only memory (PROM). This eliminates the tape loading routines and insures that, when the controller is turned on, the program is present and ready. The Model 609 has control features such as serial or parallel poll and reception of binary-coded decimal (BCD) or ASCII messages, the ability to be transparent in a large system, and a front panel pass/fail test system. The front panel contains all connectors and controls and has been designed to eliminate inadvertent false operation. The unit costs $1395. For more information, contact Physical Data Inc, Dept 37, 8220 SW Nimbus Ave, Beaverton OR 97005. Circle 485 on inquiry card.

National Introduces New Addition to One Chip Data Acquisition System Family

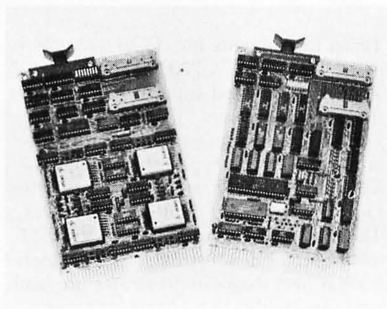


Available in two versions, the ADC0808 and ADC0809 complementary MOS (CMOS) integrated circuits incorporate the essential elements of a microprocessor-compatible data-acquisition system onto a single chip, including an 8-bit analog-to-digital (A/D) converter, an 8-channel multiplexer and microprocessor-compatible control logic. The ADC0808/09 uses a successive approximation conversion technique with a high-impedance chopper stabilized comparator which makes the device virtually immune to temperature, long term drift, and input offset errors, and it provides effective and accurate conversion while running on only 15 milliwatts. A 256R voltage ladder network approach was chosen to guarantee against missing codes. Resolution is 8 bits, and the ADC0808/09 can perform a conversion in 100 microseconds. Latched and decoded address inputs and outputs make possible interfacing to the 8080, 8085, Z80, 6800, and National's 8060 SC/MP microprocessor, among others.

For more information on prices and availability, contact Keith Mueller, National Semiconductor, 2900 Semiconductor Dr, Santa Clara CA 95051.

Circle 486 on inquiry card.

Magnetic Bubble Mass Storage for DEC Microcomputers



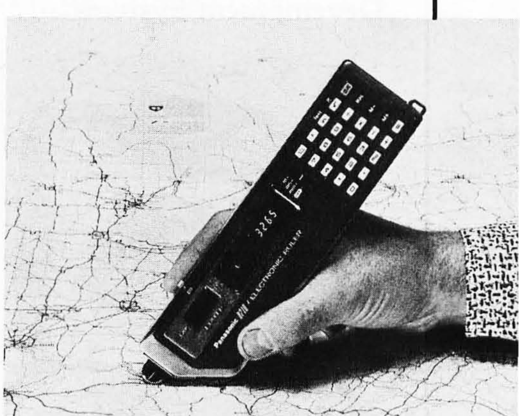
This new LSI-11-compatible bubble memory system is comprised of a dual height controller module (designated Bubbl-Board MBC-11) and one or more dual height bubble memory modules (designated Bubbl-Pac MBB-11). The MBC-11 controller contains its own 8-bit microprocessor and is capable of controlling up to 16 MBB-11 bubble memory modules. The microprocessor handles bubble device formatting and control, as well as interfacing the bubble memory system to the LSI-11 bus structure. The controller maps standard floppy disk track and sector addresses into bubble device page addresses, so that the bubble memory is fully compatible with all DEC software for the LSI-11, including the mass storage operating systems such as RT-11. The bubble memory system appears just like a floppy disk to the processor, though with much faster access time. Data storage is absolutely nonvolatile. Each MBB-11 bubble memory module uses one LSI-11 chassis slot and contains 46 K bytes of storage. Access time to the first data byte averages less than 7 ms.

The MBC-11 is priced at $650 and the MBB-11 at $950. Contact Bubbl-Tec, 3120 Crow Canyon Rd, San Ramon CA 94583. Circle 487 on inquiry card.

The Ruler That Thinks

The Panasonic Electronic Ruler/Computer uses a small displacement measuring wheel to directly measure lengths, distances, areas, and volumes, in linear, square, or cubic units, in any scale, from any document. A multifunction calculator is integrated in the ruler permitting measured data to be used automatically in computations. Intermediate measurements can be stored in the calculator's memory to yield a total quantity. The computer displays values directly in millimeters, centimeters or meters, and converts to either inches or feet simply by pressing a function key. The Electronic Ruler/Computer can measure any regular or irregular surface, such as curved walls, floors, containers, etc. Documents to be measured need not be in original scale; variations caused by reduction or enlargement can be programmed into the computer with results automatically displayed in the original scale.

Additional features include addressable memory; metric and area con-



version; percent, add-on, and discount computations; automatic square root and π; floating decimal point system; mixed calculations, and more.

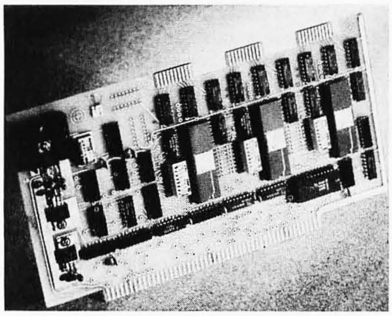
The Electronic Ruler/Computer is priced at $99.95. For further information, contact the distributors, Chafitz Inc, 1055 First St, Rockville MD 20850.

Circle 488 on inquiry card.

What's New?

MISCELLANEOUS

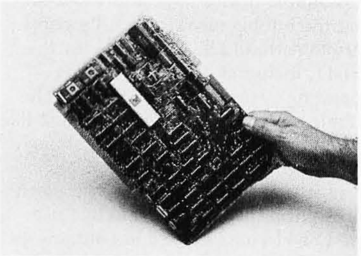
S-100 Communications Board



Designed specifically for S-100 applications, Inco's six port EIA/RS-232 board, based on the Zilog Z80A, features synchronous and asynchronous communications at a wide range of data rates. The board also contains two real-time clocks programmable in several modes, and meets the proposed IEEE S-100 standards. It performs hardware cyclic redundancy check (CRC) generation and checking, and provides standard protocol support. The board, documentation and a software guide are available for $895 from Inco Inc, 7916 Westpark Dr, McLean VA 22102.

Circle 489 on inquiry card.

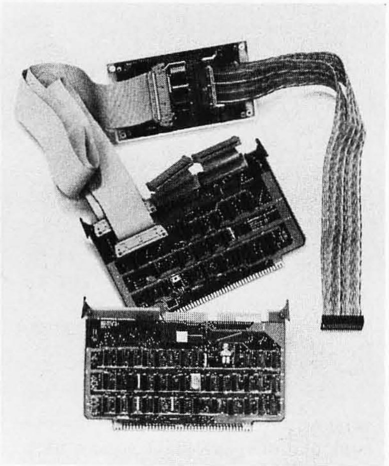
Floppy Disk Controller Board for the TM990



A floppy disk controller compatible with the TM990 series of microcomputer board products has been announced by Texas Instruments Inc, POB 1433, MS 6404, Houston TX 77001. The TM990/303 board supports up to four double-sided drives. The board is programmable for data encoding formats and number and types of disk drives. The TM990/303 has the ability to interface to single- and dual-density drives. The controller is compatible with IBM 3740 and TI disk formats. Data transfer format and steppermotor rates are both programmable. In addition, the controller also features write precompensation, soft-sector compatibility, internal phase acquisition, and address mark detection. The board is priced at $845.

Circle 490 on inquiry card.

MC6809 Microprocessor Development Systems

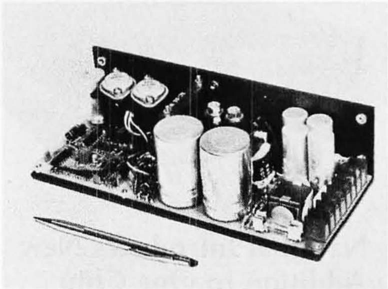


Motorola has announced six update packages to adapt a user's previous EXORciser I, IA, or II systems to MC6809 system design. These products enable designers to develop and debug any system centered around this powerful eight-bit microprocessor. The new EXORciser II and EXORterm 220 differ from the MC6800 units in current production in that they contain a microprocessing module with a M6809 component complement, as well as extending the capabilities of other internal modules to MC6809 specifications. EXORciser and EXORterm systems can be upgraded to permit M6809 designs by adding an MC6809 microprocessing module, a DEbug module, a floppy-disk controller, programmable read-only memory (PROM) firmware, and an MC6809 MDOS floppy disk, containing a macroassembler and video editor. By updating these units for operation with the MC6809 modules, the features of EXORciser II, such as dynamic systems bus, dual memory map, memory parity, second-level interrupt vectors, and more, are achievable.

The prices for the updating systems are $3200. The prices for the complete MC6809-based EXORciser and EXORterm development systems range from $7900 to $9365. For additional information, contact Motorola Inc, POB 20912, Phoenix AR 85036.

Circle 491 on inquiry card.

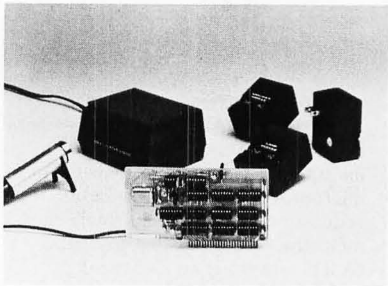
Power Saver from Power Dynamics



Power Dynamics has developed a single output open frame switcher. The unit measures 7 by 10 by 23 cm (2.75 by 4 by 9 inches). It is available in all the standard output voltages from 5 to 48 volts. The price is $175. For more information, contact Power Dynamics Corp, 9421 Telfair Ave, Sun Valley CA 91352.

Circle 492 on inquiry card.

Device for Remote Control of Electrical Devices



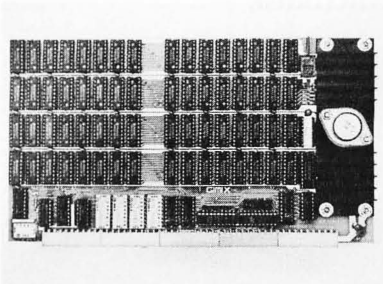
Introl/X-10 allows Apple users to remotely control 110 V AC devices by commands sent through a BSR/System X-10 Command Console over existing building wiring. The unit comes with software to control devices on predetermined schedules. It provides for selection of daily or weekly schedules, specification of the exact date for a particular event, specification of intervals of time for an event, and, for energy management, device wattage ratings for power consumption accounting. The system consists of the Introl Controller board with timer and ultrasonic transducer, the BSR/X-10 Command Console, and three Remote Modules for $279. The Introl/X-10 Controller Card costs $189 and additional remote modules are available for $15. For more information, contact Mountain Hardware Inc, 300 Harvey West Blvd, Santa Cruz CA 95060.

Circle 493 on inquiry card.

What's New?

MISCELLANEOUS

32 K Byte Static Memory Boards for 6800/6809



Gimix, 1337 W 37th Pl, Chicago IL 60609, is delivering a fully static 32 K byte programmable memory board for use with the SS-50 (6800) and SS-50C (6809) bus. The board features four independently dip-switch addressable 8 K byte blocks. Each block can be addressed to any 8 K boundary or disabled. The board is capable of decoding the four additional address lines of the SS-50C bus to allow memory decoding up to 1 M bytes. The switches enable or disable the extended addressing and set it to one of sixteen possible banks. The board is designed for high noise immunity. The price of the full 32 K board is $548.15. The 16 K version costs $328.12 and 24 K version costs $438.14. Both can be expanded to contain up to 32 K bytes of memory.

Circle 510 on inquiry card.

Lowercase and Keyboard Modification Kit for TRS-80

This kit includes wire, solder, control key, 2102 memory device, slide switch, mounting hardware, and documentation. The low power 2102 memory part is connected to a slide switch that allows the TRS-80 to be used with or without lowercase letters. To minimize the chance of damage to the 2102, its connecting wires have been pre-assembled. The control key has gold-plated contacts for long life and can be easily mounted on the keyboard. The kit is priced at $19.95, and is available from Emmanuel B Garcia Jr and Associates, 3950 N Lake Shore Dr, Rm 2310, Chicago IL 60613.

Circle 512 on inquiry card.

Low Power, 32 K Programmable Memory for Heath H8 Computers

A board with 32 K bytes of programmable memory, using less than 6 W of power and compatible with current Heath peripherals, is available from D-G Electronic Developments Co, 3223 Forest Ln, Garland TX 75042. Other features include circuit protection to prevent damage to memory output buffers if two blocks are assigned to the same address space, memory addressing controlled by a dual in-line (DIP) switch, and it is arranged as four independently addressable 8 K byte blocks with transparent refresh. The price for the board is $479, and it comes fully assembled and tested.

Circle 511 on inquiry card.

What's New?

MISCELLANEOUS

tinyFORTH 2.1 for TRS-80

The Software Farm, POB 2304, Reston VA 22090 has developed the tinyFORTH 2.1 system for TRS-80 systems. Programs written in tinyFORTH can run faster and use less memory than similar programs in BASIC because tinyFORTH includes a compiler in addition to an interpreter. This system includes a powerful text editor, a Z80 assembler, and a graphics package. The tinyFORTH system occupies 8 K bytes of memory and comes with cassette tape and documentation for 16 K Level II TRS-80s. The system costs $29.95.

Circle 500 on inquiry card.

32 K Structured BASIC

Cromemco 32 K Structured BASIC, which runs in 64 K Cromemco Systems, assists a programmer in building a program from logical blocks of code. This facilitates program development and reduces debugging and maintenance of programs. It contains all features of 16 K BASIC plus long variable names of up to 31 characters, statement labels that replace statement numbers to reference lines in a BASIC program, an in-line BASIC editor, a keyed sequential access method (KSAM), procedures, and control structures including *if . . . then . . . else,while . . . endwhile*, and *repeat . . . until*.

Cromemco 32 K Structured BASIC is available for use on Cromemco systems on 8-inch or 5-inch floppy disks for $295. For additional information, contact Cromemco Inc, 280 Bernardo Ave, Mountain View CA 94043.

Circle 501 on inquiry card.

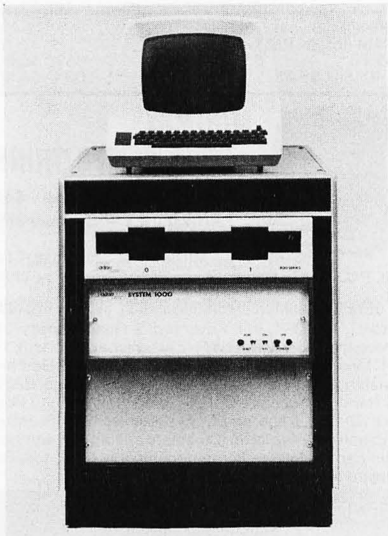
Motorola Introduces MC68000 Design Module

Motorola has introduced the MEX68KDM, an MC68000 design module. The MEX68KDM permits easy chip evaluation, using either an EXORciser development system or an IBM370 or PDPII, in conjunction with cross-computer software. For system emulation, the module includes 32 K bytes of programmable memory, two 16-bit parallel input/output (I/O) ports, three 16-bit programmable timers and two serial RS-232 ports.

MEX68KDM includes MACSbug, a powerful 16-bit microprocessor debugging tool. Once a memory file is resident in programmable memory, a user may begin his program debugging. The memory map for the MEX68KDM allows for the use of any of the on-card I/O and additional external memory or I/O. A 6800 bus interface card is provided to allow the MEX68KDM to read or write data to an external memory or I/O card. The design module may be used in a stand-alone mode, in an EXORciser development system in the nonexpanded bus mode, or in a card cage with standard 6800 memory.

The design module with two RS-232 cables is priced at $1795. Contact Motorola Semiconductor Inc, POB 20912, Phoenix AZ 85036, for more information.

Circle 502 on inquiry card.

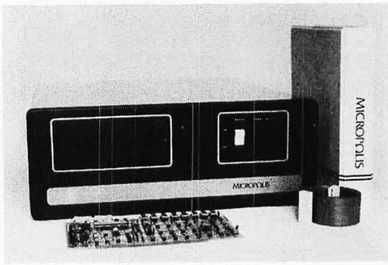


PROSYS I System

Aimed primarily at the process control and industrial/measurement markets, the system allows a process control engineer or technician to communicate with a digital computer-controlled process system. PROSYS I includes the ADAC System 1000 enclosure with the 64 K byte version of the Digital Equipment Corp LSI-11/2 microcomputer, dual-port serial interface, single drive, double-density floppy disk and video terminal. The software resides in less than 32 K bytes of memory. The software includes an operating system. The system can accomodate up to eighteen PROSYS I optional modules. The price for the system is $14,000, and it is available from ADAC Corp, 70 Tower Office Park, Woburn MA 01801.

Circle 503 on inquiry card.

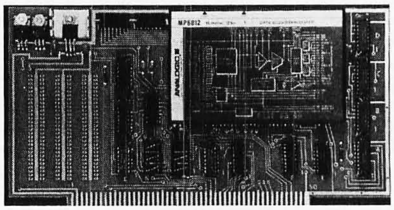
Multiuser Operating System for Micropolis Microdisk



Micropolis Corp, 7959 Deering Ave, Canoga Park CA 91304, is marketing their fully integrated rigid disk subsystem which includes their 8-inch rigid disk drive with up to 31.2 M bytes of formatted data storage capacity, an intelligent disk adapter-interface card, and a software package for microcomputer systems that use the S-100 bus. The Microdisk subsystems are available in capacities of 6.2, 18.7 and 31.2 M bytes and are expandable by daisy chaining. Up to three add-on modules may be connected to a master unit. Prices for the Microdisk system begin at under $5000.

Circle 504 on inquiry card.

S-100 16-Channel 12-Bit Analog to Digital Converter Board



The Tecmar S-100 Analog to Digital (A/D) board interfaces the Analogic MP 6812 Complete Data Acquisition System to the S-100 bus. The board accepts sixteen single ended inputs and has data rates up to 30 kHz with twelve bit accuracy. The total of multiplex settling time and sample-hold acquisition time is about 7 microseconds. The board provides two's complement right-justified outputs and variable voltage ranges. The board may be configured to act as an input/output (I/O) device or to act as a memory mapped device. The board requires little software. The price is $495, and it is available from Tecmar Inc, 23414 Greenlawn Ave, Cleveland OH 44122.

Circle 505 on inquiry card.

What's New?

MISCELLANEOUS

Network Information Resource

The SOURCE is a computer-based electronic message and information system. It allows users to send messages over computer terminals via a nationwide switching network. The SOURCE provides advanced electronic mail features such as text editing, scanning, delayed delivery, interactive conversation, and bulletin boards. It also acts as an information supermarket offering news, educational programs, travel and shopping services, and much more. To use the SOURCE, subscribers need only a microcomputer or terminal. The cost of the service is $100 initial registration fee plus $2.75 an hour. The service is $15 an hour between 7 AM and 6 PM, Monday thru Friday. For information, contact Telecomputing Corp of America, 1616 Anderson Rd, McLean VA 22102.

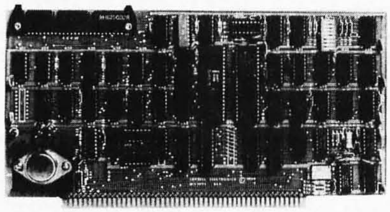
Circle 506 on inquiry card.

S-100 Card Adds Sound

Two General Instrument AY-3-8910 programmable sound generators are interfaced to the S-100 bus on the Noisemaker to create sounds and noises. The board provides six tone generators, two noise sources, two envelope generators and four 8-bit input/output ports. Sound effects and noises may be created and added to graphics and computer games. An on-board audio amplifier and breadboard area allows inclusion of the board into any system. The Noisemaker is available now as an unpopulated, solder masked and screened, printed circuit board for $34.95. Contact Ackerman Digital Systems, Suite 208, 110 York Rd, Elmhurst IL 60126.

Circle 507 on inquiry card.

Double-Density Floppy Disk Interface



Tarbell Electronics has released its new interface board, which is supplied with the BASIC INPUT/OUTPUT SYSTEM software for CP/M on single-density floppy disk, permitting users to mix single- and double-density disks. As many as four drives can be selected, using either single- or double-density. The 8-inch, Shugart-compatible disk interface contains phase-lock-loop and write precompensation, and the bootstrap programmable read-only-memory (PROM) is disabled on completion of the bootstrap operation, freeing all 64 K bytes of memory for other use. Extended addressing capability provides eight additional address bits as specified by the new IEEE standard, allowing direct transfers to and from any location within a 16 M byte address range. The interface comes with BIOS for CP/M on floppy disk for $425 from Tarbell Electronics, 950 Dovlen Pl, Suite B, Carson CA 90746.

Circle 508 on inquiry card.

Package Turns Exidy Sorcerer into Z80 Development System



Available for $99, a software package called the Development Pac can turn an Exidy Sorcerer into a sophisticated, cassette-based, Z80 development system. The package includes four modules: a designer's debugging tool (DDT), a line-oriented text editor, a relocating assembler, and a linking loader. All can operate with the Sorcerer's dual cassette interface to allow tape-based system development. The system supports global symbols for intermodule communication and allows the user to define the input/output (I/O) devices for source code, object code, and listings. The debugging tool allows the user to display and modify any programmable memory location or any Z80 register. Using the Development Pac, a programmer can design a program that is far larger than the Sorcerer's memory without having to worry about size limits, due to partitioning of memory and two predefined buffers that can be used for program storage. The package is available from Exidy Data Systems, 2599 Garcia Ave, Mountain View CA 94043.

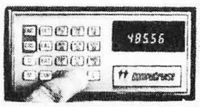
Circle 509 on inquiry card.

 Circle 164 on inquiry card.

COMPUCRUISE

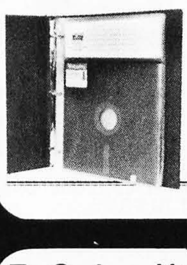
Put a computer in your car, which gives you the most effective and functional cruise control ever designed, plus complete trip computing, fuel management systems, and a remarkable accurate quartz crystal time system.

So simple a child can operate, the new CompuCruise combines latest computer technology with state-of-the-art reliability in a package which will not likely be available on new cars for years to come • Cruise Control • Time, E.T., Lap Timer, Alarm • Time, Distance, Fuel to Arrival • Time, Distance, Fuel to Empty • Time, Distance and Fuel on Trip • Current or Average MPG, GPH • Fuel Used, Distance since Fillup • Current and Average-Vehicle Speed • Inside, Outside or Coolant Temperature • Battery Voltage • English or Metric Display. $169.95 , without cruise control $129.95.



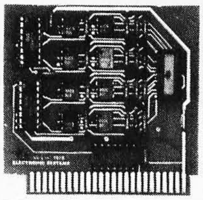
FLOPPY DISK STORAGE BINDER

This black vinyl three-ring binder comes with ten transparent plastic sleeves which accommodate either twenty, five-inch or ten, eight-inch floppy disks. The plastic sleeves may be ordered separately and added as needed. A contents file is included with each sleeve for easy identification and organizing. Binder & 10 holders $14.95 Part No. B800; Extra holders 95¢ each. Part No. 800



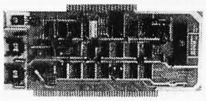
OPTO-ISOLATED PARALLEL INPUT BOARD FOR APPLE II

There are 8 inputs that can be driven from TTL logic or any 5 volt source. The circuit board can be plugged into any of the 8 sockets of your Apple II. It has a 16 pin socket for standard dip ribbon cable connection.
Board only $15.00. Part No. 120, with parts $69.95. Part No. 120A.



TIDMA

• Tape Interface Direct Memory Access • Record and play programs without bootstrap loader (no prom) has FSK encoder/decoder for direct connections to low cost recorder at 1200 baud rate, and direct connections for inputs and outputs to a digital recorder at any baud rate • S-100 bus compatible • Board only $35.00 Part No. 112, with parts $110 Part No. 112A

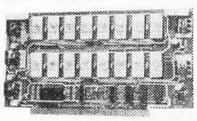


SYSTEM MONITOR

8080, 8085, or Z-80 System monitor for use with the TIDMA board. There is no need for the front panel. Complete with documentation $12.95.

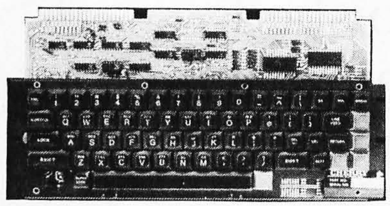
16K EPROM

Uses 2708 EPROMS, memory speed selection provided, addressable anywhere in 65K of memory, can be shadowed in 4K increments. Board only $24.95 part no. 7902, with parts less EPROMs $49.95 part no. 7902A.



ASCII KEYBOARD

TTL & DTL compatible • Full 67 key array • Full 128 character ASCII output • Positive logic with outputs resting low • Data Strobe • Five user-definable spare keys • Standard 22 pin dual card edge connector • Requires +5VDC, 325 mA. Assembled & Tested. Cherry Pro Part No. P70-05AB. $119.95.



ASCII KEYBOARD

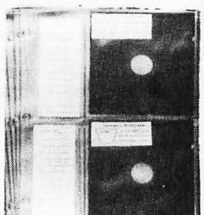
53 Keys popular ASR-33 format • Rugged G-10 P.C. Board • Tri-mode MOS encoding • Two-Key Rollover • MOS/DTL/TTL Compatible • Upper Case lockout • Data and Strobe inversion option • Three User Definable Keys • Low contact bounce • Selectable Parity • Custom Keycaps • George Risk Model 753. Requires +5, -12 volts. $59.95 Kit.

ASCII TO CORRESPONDENCE CODE CONVERTER

This bidirectional board is a direct replacement for the board inside the Trendata 1000 terminal. The on board connector provides RS-232 serial in and out. Sold only as an assembled and tested unit for $229.95. Part No. TA 1000C

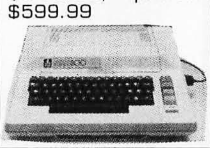
DISK JACKET™

Made from heavy duty .0095 matte plastic with reinforced grommets. The mini-diskette version holds two 5-1/4 inch diskettes and will fit any standard three ring binder. The pockets to the left of the diskette can be used for listing the contents of the disk. Please order only in multitudes of ten. $9.95/10 Pack.



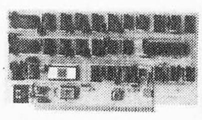
ATARI 800

Computer with 8K $995.00, disk drive $549.00, printer $599.99



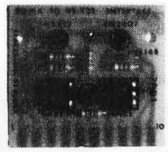
VIDEO TERMINAL

16 lines, 64 columns • Upper and lower case • 5x7 dot matrix • Serial RS-232 in and out with TTL parallel keyboard input • On board baud rate generator 75, 110, 150, 300, 600, & 1200 jumper selectable • Memory 1024 characters (7-21L02) • Video processor chip SFF96364 by Neculonic • Control characters (CR, LF, →, ←, ↑, ↓, non destructive cursor, CS, home, CL • White characters on black background or vice-versa • With the addition of a keyboard, video monitor or TV set with TV interface (part no. 107A) and power supply this is a complete stand alone terminal • also S-100 compatible • requires +16, & −16 VDC at 100mA, and 8VDC at 1A. Part No. 1000A $199.95 kit.



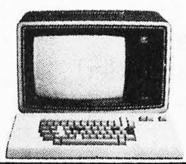
RS-232/20mA INTERFACE

This board has two passive, opto-isolated circuits. One converts RS-232 to 20mA, the other converts 20mA to RS-232. All connections go to a 10 pin edge connector. Requires +12 and -12 volts. Board only $9.95, part no. 7901, with parts $14.95 Part No. 7901A.



COMPUCOLOR II

Model 3, 8K $13 95, Model 4, 16K $14 95, Model 5, 32K $16 95. Prices include color monitor, computer, and one disk drive.



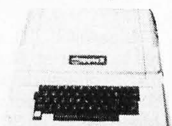
PET COMPUTER

With 16K & monitor - $ 795. Dual Disk Drive - $10 95

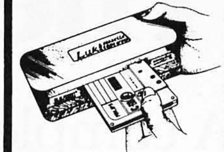


apple II or APPLE II PLUS

16K - $975, 32K - $1059, 48K - $1123. Disk & cont. $589



CASSETTE TAPE ERASER



REMOVES RECORDINGS IN ONE SECOND! The process eliminates static positive / negative ions and maintains original tone quality with minimal tape hiss • To improve tone quality • To reduce hissing • For quick and easy to erase • No battery or liquid required • Powerful and effective action • Unconditional 2 year guarantee. ERASER-8 $19.95.

16K RAMS

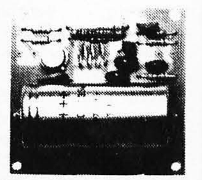
For the Apple, TRS-80 or Pet $8 each Part No. 4116/2117.

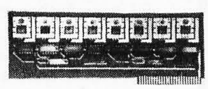
APPLE II HOBBY/ PROTOTYPING CARD

$14.95 Part No. 7907

T.V. INTERFACE

● Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple ● Power required is 12 volts AC C.T., or +5 volts DC ● Board only $7.60 part No. 107, with parts $13.50 Part No. 107A





PARALLEL TRIAC OUTPUT BOARD FOR APPLE II

This board has 8 triacs capable of switching 110 volt 6 amp loads (660 watts per channel) or a total of 5280 watts. Board only $15.00 Part No. 210, with parts $119.95 Part No. 210A.

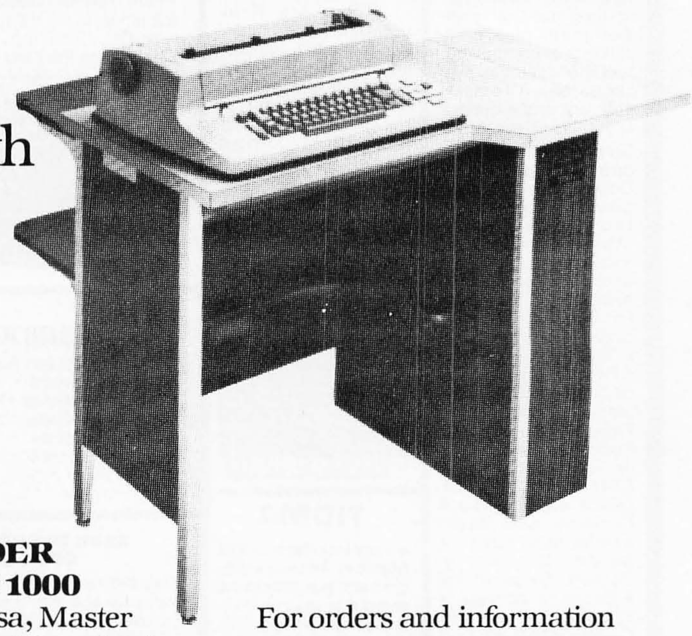
To Order: Mention part no. description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U.S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U.S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800

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Circle 165 on inquiry card.

The DATA-TRANS 1000



A completely refurbished **IBM** Selectric Terminal with built-in **ASCII** Interface.

$1495

Features:

- 300 Baud
- 14.9 characters per second printout
- Reliable heavy duty Selectric mechanism
- RS-232C Interface
- Documentation included
- 60 day warranty - parts and labor
- High quality Selectric printing Off-line use as typewriter
- Optional tractor feed available
- 15 inch carriage width

HOW TO ORDER DATA-TRANS 1000

1. We accept Visa, Master Charge. Make cashiers checks or personal check payable to:

DATA-TRANS

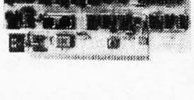
2. All orders are shipped F.O.B. San Jose, CA
3. Deliveries are immediate

For orders and information

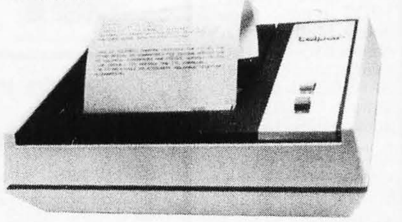
DATA-TRANS
2154 O'Toole St.
Unit E
San Jose, CA 95131
Phone: (408) 263-9246

SERIAL I/O

Four Serial I/O RS-232 ports, S-100 Bus, Software or jumper selectable baud rates (110, 300, 600, 1200, 2400, 4800, 9600, 19.2K), on board Xtal baud rate generator, Addressing, switch selectable, Parity or no parity (odd or even) switch selectable, 1 or 2 stop bits, 5 to 8 bits/character. Board only $29.95, Part No. 7908. With parts (kit) $199.95, Part No. 7908A.



TELPAR



TTL parallel, TTL serial, RS232C serial, 20 mil loop serial. Quiet, clean — no ribbons or ink; 24 characters/second; Upper/lower case 96 ASCII characters; Signalling rates: Serial Mode — 110 or 300 Baud; Parallel mode — up to 960 characters/second; For applications over 48 columns, automatically prints on next line; Prints 1 character at a time — ideal for interactive applications; Local line feed for advancing paper; Parity check (odd, even or none); ASCII control codes: back space, carriage return, line feed (implemented as a new line), vertical tab (1 line), negative vertical tab (on receipt of ESC, VT), Bell (9 microsecond pulse on receipt of BEL) PS-48C Printer $699, with Keyboard, $895. Paper roll 5½"x164' $3.00

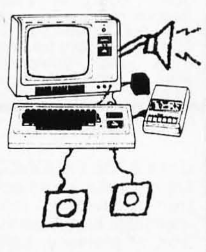
44 BUS MOTHER BOARD

Has provisions for ten 44 pin (.156) connectors, spaced 3/4 of an inch apart. Pin 20 is connected to X, and 22 is connected to Z for power and ground. All the other pins are connected in parallel. This board also has provisions for bypass capacitors. Board cost $15.00 Part No. 102. Connectors $3.00 each Part No. 44WP.



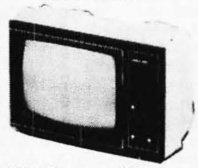
GAME PADDLES & SOUND

For Your TRS 80 (Level II or Disk)



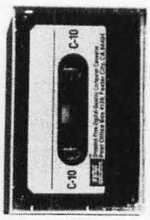
Includes: 2 game paddles, interface, software, speaker, power supply, full documentation including: schematics, theory of operation, and user guide; plus 2 games on cassette (Pong and Starship War). $79.95 Complete Part No. 7922C

LEEDEX MONITOR



12" Black and White • 12 MHz Bandwidth • Handsome Plastic Case • $139.00

DIGITAL CASSETTE



5 min. each side. Box of 10 $9.95.

To Order: Mention part no. description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U.S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U.S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800

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Circle 164 on inquiry card.

Circle 166 on inquiry card.

Circle 167 on inquiry card.

Circle 168 on inquiry card.

Circle 170 on inquiry card.

Circle 171 on inquiry card.

Circle 172 on inquiry card.

Circle 173 on inquiry card.

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P.O. Box 4430X Santa Clara, CA 95054
For will call only: (408) 988-1640
2322 Walsh Ave.

Quest ELECTRONICS

NEW PRODUCTS!

Super Color S-100 Video Kit $99.95
Expandable to 256 x 192 high resolution color graphics. 6847 with all display modes computer controlled. Memory mapped. 1K RAM expandable to 6K. S-100 bus 1802, 8080, 8085, Z80 etc.

Gremlin Color Video Kit $59.95
32 x 16 alpha/numerics and graphics; up to 8 colors with 6847 chip; 1K RAM at E000. Plugs into Super Elf 44 pin bus. Not expandable to high resolution Graphics.

Elf II Adapter Kit $24.50
Plugs into Elf II providing Super Elf 44 and 50 pin bus plus S-100 bus expansion (With Super Expansion). High and low address displays, state and mode LED's optional **$18.00.**

1802 16K Dynamic RAM Kit $149.00
1802/S-100 expandable to 32K, Hidden refresh w/clocks up to 4 MHz w/no wait states Addl. 16K RAM **$79.00.**

Quest Super Basic
Quest, the leader in inexpensive 1802 systems announces another first. Quest is the first company worldwide to ship a **full size Basic** for 1802 systems. A complete function **Super Basic** by **Ron Cenker** including floating point capability with scientific notation (number range ±.17E[38]), 32 bit integer ±2 billion; Multi dim arrays; String arrays; String manipulation; Cassette I/O, Save and load, Basic, Data and machine language programs; and over 75 Statements, Functions and Operators.

Easily adaptable on most 1802 systems. Requires 12K RAM minimum for Basic and user programs. Cassette version in stock now. ROM versions coming soon with exchange privilege allowing some credit for cassette version.

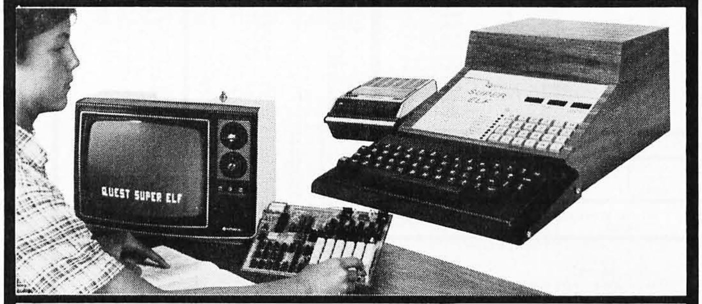
Super Basic on Cassette $40.00

Tom Pittman's 1802 Tiny Basic Source listing now available. Find out how Tom Pittman wrote Tiny Basic and how to get the most out of it. Never offered before. $19.00

S-100 4-Slot Expansion $ 9.95

Super Monitor VI.I Source Listing $15.00

Coming Soon: Assembler, Editor, Disassembler, DA/AD, Super Sound/Music, EPROM programmer.



RCA Cosmac Super Elf Computer $106.95
Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded** with **additional memory, Full Basic, ASCII Keyboards, video character generation, etc.**

Before you buy another small computer, see if it includes the following features: ROM monitor; State and Mode displays; Single step; Optional address displays; Power Supply; Audio Amplifier and Speaker; Fully socketed for all IC's; Real cost of in warranty repairs; Full documentation.

The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest** address and data bus displays **before, during** and **after** executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, wait, input, memory protect, monitor select** and **single step**. Large, on board displays provide output and optional **high** and **low address**. There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for **all** IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game.

Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and research and development.

Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95.** Expansion Cabinet with room for 4 S-100 boards **$41.00. NiCad Battery Memory Saver Kit $6.95.** All kits and options also completely assembled and tested.

Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for $12.00 per year.

Tiny Basic Cassette **$10.00**, on ROM **$38.00**, original Elf kit board **$14.95. 1802 software;** Moews Video Graphics **$3.50.** Games and Music **$3.00,** Chip 8 Interpreter **$5.50.**

Super Expansion Board with Cassette Interface $89.95
This is truly an astounding value! This board has been designed to allow **you** to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface**. Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf**. The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed.** EPROM can be used for the monitor and Tiny Basic or other purposes.

A IK Super ROM Monitor $19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/ editor and error checking multi file cassette read/write software, (relocatable cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. The Super Monitor is written with subroutines allowing users to take advantage of monitor functions simply by calling them up. Improvements and revisions are easily done with the monitor. If you have the **Super Expansion Board** and **Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports** with **full handshake.** They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set** with ribbon cable is available at $15.50 for easy connection between the **Super Elf** and the **Super Expansion Board.**

Power Supply Kit for the complete system (see Multi-volt Power Supply).

Same day shipment. First line parts only. Factory tested. Guaranteed money back. Quality IC's and other components at factory prices.

INTEGRATED CIRCUITS

7400TTL

Part	Price
7400N	.17
7402N	.18
7404N	.19
7409N	.23
7410N	.18
7414N	.70
7420N	.18
7422N	.39
7430N	.20
7442N	.50
7445N	.69
7447N	.60
7448N	.69
7450N	.18
7474N	.35
7475N	.49
7485N	.88
7489N	1.85
7490N	.43
7492N	.43
7493N	.43
7495N	.69
74100N	.90
74107N	.35
74121N	.34
74123N	.59
74125N	.45
74145N	.69
74150N	.95
74151N	.69
74154N	1.00
74157N	.69
74161N	.87
74162N	.87
74163N	.87
74174N	.96
74175N	.90
74190N	1.15
74192N	.87
74193N	.85
74221N	2.00
74298N	1.65
74365N	.66
74366N	.66
74367N	.66

74LS00 TTL

Part	Price
74LS00N	.35
74LS02N	.35
74LS04N	.35
74LS05N	.35
74LS08N	.35
74LS10N	.35
74LS13N	.55
74LS14N	1.10
74LS20N	.35
74LS22N	.35
74LS28N	.41
74LS30N	.35
74LS33N	.75
74LS38N	.55
74LS74N	1.25
74LS75N	1.00
74LS90N	.85
74LS93N	.70
74LS95N	1.10
74LS107N	.45
74LS112N	.45
74LS113N	.35
74LS132N	.89
74LS136N	.45
74LS151N	.85
74LS155N	.85
74LS157N	.85
74LS162N	1.15
74LS163N	1.15
74LS174N	2.00
74LS190N	1.06
74LS221N	1.95
74LS258N	.67
74LS367N	1.35

LINEAR

Part	Price
CA3045	.90
CA3046	1.10
CA3081	1.80
CA3082	1.90
CA3089	2.95
LM301AN/AH	.35
LM305H	.87
LM307N	.35
LM308N	.89
LM309K	1.50
LM311H/N	.90
LM317T/K	3.75
LM318	1.35
LM320K-5	1.50
LM323K-5	5.95
LM320K-12	1.50
LM320K-15	1.50
LM320T-5	1.60
LM320T-8	1.60
LM320T-12	1.50
LM320T-15	1.60
LM324N	1.15
LM339N	1.55
LM340K-5	1.35
LM340K-8	1.35
LM340K-12	1.35
LM340K-15	1.35
LM340K-24	1.35
LM340T-5	1.25
LM340T-8	1.25
LM340T-12	1.25
LM340T-15	1.25
LM340T-18	1.25
LM340T-24	1.25
LM343H	4.50
LM350	7.50
LM370	1.15
LM377	3.00
LM379	5.00
LM380N	1.00
LM381	1.60
LM382	1.60
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LM709H	.28
LM723H/N	.50
LM733N	.67
LM741CH	.35
LM741N	.32
LM747H/N	.75
LM748N	.35
LM1303N	1.75
LM1304	1.10
LM1305	1.27
LM1307	2.00
LM1310	2.75
LM1458	.47
LM1800	1.75
LM1812	7.50
LM1889	3.00
LM2111	1.75
LM2902	1.50
LM3900N	.60
LM3905	1.75
LM3909N	.89
MC1458V	.50
NE540H	3.75
NE550N	1.00
NE555V	.39
NE556A	.85
NE565A	1.00
NE566V	1.50
NE567V	1.00
NE570B	5.00
78L05	.60
78L08	.60
78M05	.85
75108	1.75
75491CN	.50
75492CN	.55
75494CN	.89

A to D CONVERTER

Part	Price
8038B	4.50
8700CJ	13.95
8701CN	22.00
8750CJ	13.95
LD130	9.95
9400CJV/F	7.40
ICL7103	9.50
ICL7107	14.25

CMOS

Part	Price
CD34001 Fair.	.50
CD4000	.16
CD4001	.28
CD4002	.28
CD4006	1.10
CD4007	.28
CD4008	.28
CD4009	.45
CD4010	.45
CD4011	.28
CD4012	.28
CD4013	.39
CD4014	1.00
CD4015	1.00
CD4016	.45
CD4017	1.05
CD4018	.94
CD4019	.45
CD4020	1.02
CD4021	1.25
CD4022	1.10
CD4023	.28
CD4024	.75
CD4025	.28
CD4026	2.00
CD4027	.66
CD4028	.85
CD4029	1.02
CD4030	.45
CD4035	1.02
CD4040	1.02
CD4042	.85
CD4043	.85
CD4044	.85
CD4046	1.67
CD4049	.45
CD4050	.49
CD4051	1.13
CD4060	1.42
CD4066	.71
CD4068	.40
CD4069	.40
CD4070	.50
CD4071	.28
CD4072	.28
CD4073	.28
CD4075	.28
CD4076	1.45
CD4078	.40
CD4081	.28
CD4082	.28
CD4116	.47
CD4490	5.50
CD4507	1.00
CD4508	4.25
CD4510	1.02
CD4511	.94
CD4515	2.52
CD4516	1.10
CD4518	1.02
CD4520	1.02
CD4527	1.51
CD4528	.79
CD4553	3.50
CD4566	2.25
CD4583	4.50
CD4585	1.10
CD40192	3.00
74C00	.28
74C04	.40
74C10	.28
74C14	2.10
74C20	.28
74C30	.28
74C48	1.95
74C74	.75
74C76	1.40
74C90	1.15
74C93	1.40
74C154	3.00
74C160	1.44
74C175	1.35
74C192	1.65
74C221	2.00
74C905	6.00
74C906	.75
74C914	1.95
74C922	5.50
74C923	5.50
74C925	6.95
74C926	6.95
74C927	6.95

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Part	Price
8095	.65
8096	.65
8097	.65
8098	.65
8T09	1.25
8T10	4.50
8T13	3.00
8T20	5.50
8T23	3.10
8T24	3.50
8T25	3.20
8T26	1.69
8T28	2.75
8T97	1.69
8T98	1.69

MOS/MEMORY RAM

Part	Price
2101-1	3.95
2102-1	.95
2102AL-4	1.25
2102AN-2L	1.60
21L02-1	1.18
21F02	1.25
2104A-4	4.95
2107B-4	3.75
2111-1	3.75
2112-2	3.95
2114L-1	7.40
2114L-3	7.90
4116	10.95
2513B	6.30
MM5262	.40
MM5280	3.00
MM5320	9.95
MM5330	5.94
PD411D-3	4.00
PD411D-4	5.00
P5101L	13.95
4200A	9.95
82S25	2.90
91L02A	1.50
HD0165-5	6.95
MM57100	4.50
GIAY38500-1	9.95
MCM6571A	9.95
9368	3.50
410D	10.00
416	16.00

CLOCKS

Part	Price
MM5314	3.90
MM5369	2.10
MM5841	14.45
MM5865	7.95
CT7001	5.80
CT7010	8.95
MM5375AA/N	3.90
MM5375AG/N	4.90
7205	16.50
7207	7.50
7208	15.95
7209	4.95
DS0026CN	3.75
DS0056CN	3.75
MM53104	2.50

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Part	Price
6800	17.50
6802	18.75
8080A	8.95
8085	27.00
Z80	14.75
Z80A	19.75
8212	2.90
8214	8.00
8216	2.90
8224	2.90
8228	5.35
8251	8.50
8253	15.00
8255	9.25
8257	19.50
8259	19.50
1802CP plas.	13.95
1802DP plas.	17.95
1861P	11.50
CDP1802CD	19.95
CDP1802D	25.00
CDP1861	12.95
6820	9.95
6850	12.95
6502	12.50
6504	16.50
6522	13.60

UART/FIFO

Part	Price
AY5-1013	5.50
AY5-1014	7.50
3341	6.95

PROM

Part	Price
1702A	3.95
2708	10.50
2716T1	29.50
2716 Intel	48.00
2732	115.00
2758	22.50
8741A	85.00
8748	75.00
8748-8	60.00
8755A	65.00
N82S23	2.95
N82S123	3.50
N82S126	3.75
N82S129	3.75
N82S131	3.75
N82S136	8.75
N82S137	8.75
DM8577	2.90
8223	2.90

CONNECTORS

Item	Price
30 pin edge	2.50
44 pin edge	2.75
100 pin edge	4.50
100 pin edge WW	5.25

IC SOCKETS
Solder Tin Low Profile

PIN	1 UP	PIN	1UP
8	.15	22	.30
14	.14	24	.35
16	.16	28	.42
18	.27	36	.58
20	.29	40	.57

2 level 14 pin ww .20

WIRE WRAP LEVEL 3

PIN		PIN	
14	.32	24	.86
16	.33	28	1.00
18	.57	40	1.23

CRYSTALS

Item	Price
1 MHz	4.50
2 MHz	4.50
4 MHz	4.25
5 MHz	4.25
10 MHz	4.25
18 MHz	3.90
20 MHz	3.90
32 MHz	3.90
32768 MHz	4.00
1.8432 MHz	4.50
3.5795 MHz	1.20
2.0100 MHz	1.95
2.097152 MHz	4.50
2.4576 MHz	4.50
3.2768 MHz	4.50
5.0688 MHz	4.50
5.185 MHz	4.50
5.7143 MHz	4.50
6.5536 MHz	4.50
14.31818 MHz	4.25
18.432 MHz	4.50
22.1184 MHz	4.50

KEYBOARD ENCODERS

Part	Price
AY5-2376	$12.50
AY5-3600	17.95
74C922	5.50
74C923	5.50
HD0165-5	6.95

D Connectors RS232

Part	Price
DB25P	2.95
DB25S	3.95
Cover	1.50
RS232 Complete Set	6.50
DE9S	1.95
DA15P	2.10
DA15S	3.10

Hickok 3½ Digit LED multimeter 69.95
Stopwatch Kit 26.95
Auto Clock Kit 17.95

TRANSISTORS

Part	Price
2N1893	.40
2N222A	.27
2N2369	.30
2N2904A	.20
2N2907A	.25
2N3053	.40
2N3638	.25
2N3643	.25
2N3904	.18
2N3906	.18
2N3055	.69
2N4400	.25
2N4401	.75
2N4402	.20
TIP31	.60
TIP33A	1.00

RESISTORS ¼ watt 5%
10 per type .03 — 1000 per type .012
25 per type .025 — 350 piece pack
100 per type .015 — 5 per type 6.75
½ watt 5% per type .05

KEYBOARDS

Item	Price
56 key ASCII keyboard kit	$67.50
Fully assembled	77.50
53 key ASCII keyboard kit	60.00
Fully assembled 70.00 Enclosure	14.95

LEDS

Item	Price
Red T018	.15
Green, Yellow T018	.20
Jumbo Red	.20
Green, Orange, Yellow Jumbo	.25
Cliplite LED Mounting Clips	8/$1.25

(specify red, amber, green, yellow, clear)

CONTINENTAL SPECIALTIES in stock
Complete line of breadboard test equip.
MAX-100 8 digit Freq. Ctr. $128.95

OK WIRE WRAP TOOLS in stock
Portable Multimeter $18.00

SPECIAL PRODUCTS

Item	Price
MM5865 Stopwatch Timer	9.00
PC board	7.50
Switches Mom. Pushbutton	.27
3 pos. slide	.25
Encoder HD0165-5	6.95
3 Digit Universal Counter Board Kit Operates 5–18 Volt DC to 5 MHz typ. .125" LED display	**10.50**
Paratronics 100A Logic Analyzer Kit	**$224.00**
Model 10 Trigger Expander Kit	$229.00
Model 150 Bus Grabber Kit	$369.00
Sinclair 3½ Digit Multimeter	**$59.95**
Clock Calendar Kit	**$23.95**
2.5 MHz Frequency Counter Kit	**$37.50**
30 MHz Frequency Counter Kit	**$47.75**

TRANSFORMERS

Item	Price
6V 300 ma	3.25
12 Volt 300 ma transformer	1.25
12.6V CT 600 ma	3.75
12V 250 ma wall plug	2.95
12V CT 250 ma wall plug	3.50
24V CT 400 ma	3.95
10V 1.2 amp wall plug	4.85
12V 6 amp	12.95
12V 500 ma wall plug	4.75
12V 1 amp wall plug	6.50
12V 3 amp wall plug	8.50

DISPLAY LEDS

Part	Type	Size	Price
MAN1	CA	.270	2.90
MAN3	CC	.125	.39
MAN72/74	CA/CA	.300	1.00
DL704	CC	.300	1.25
DL707/DL707R	CA	.300	1.00
DL727/728	CA/CC	.500	1.90
DL747/750	CA/CC	.600	1.95
DL750	CC	.600	1.95
FND359	CC	.357	.70
FND500/507	CC/CA	.500	1.35
FND503/510	CC/CA	.500	.90
FND800/807	CC/CA	.800	2.20
3 digit Bubble			.60
4 digit Bubble			.80
DG8 Fluorescent			1.75
DG10 Fluorescent			1.75
5 digit 14 pin display			1.00
NSN69 9 digit display			.60
7520 Clairex photocells			.39
TIL311 Hex			9.50
MAN3640	CC	.30	1.10
MAN4610	CA	.40	1.20
MAN4640	CC	.40	1.20
MAN4710	CA	.40	.95
MAN4740	CC	.40	1.20
MAN6640	CC	.56	2.95
MAN6710	CA	.60	1.35
MAN6740	CC	.60	1.35
MA1002A			**8.95**
MA1012A			**8.95**
102P3 transformer			**2.25**

ROCKWELL AIM 65 Computer
6502 based single board with full ASCII keyboard and 20 column thermal printer. 20 char. alphanumeric display, ROM monitor, fully expandable. $375.00. 4K version $450.00. 4K Assembler $85.00, 8K Basic Interpreter $100.00.

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AIM 65/KIM/VIM/Super Elf 44 pin expansion board; 3 female and 1 male bus. Board plus 3 connectors **$22.95.**

AIM 65/KIM/VIM I/O Expansion Kit; 4 parallel and 2 serial ports plus 2 internal timers **$39.00.** PROM programmer for 2716 **$150.00.**

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Will erase 25 PROMs in 15 minutes. Ultraviolet, assembled **$37.50**

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Converts digital clocks from AC line frequency to crystal time base. Outstanding accuracy.

79 IC Update Master Manual $35.00
Complete IC data selector, 2500 pg. master reference guide. Over 50,000 cross references. Free update service through 1979. Domestic postage $3.50. No foreign orders.

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Includes everything except case. 2-PC boards. 6-.50" LED Displays. 5314 clock chip, transformer, all components and full instructions. Orange displays also avail. **Same kit w/.80" displays.** Red only. **$21.95.** Case **$11.75**

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Opens shorted cells that won't hold a charge and then charges them up, all in one kit w/full parts and instructions. **$7.25**

S-100 Computer Boards

Item	Price
8K Static RAM Kit	$135.00
16K Static RAM Kit	265.00
24K Static RAM Kit	423.00
32K Static RAM Kit	475.00
16K Dynamic RAM Kit	199.00
32K Dynamic RAM Kit	310.00
64K Dynamic RAM Kit	470.00
8K/16K Eprom Kit (less PROMS)	**$89.00**
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Motherboard **$39.** Extender Board	**$8.99**

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Convert your TV set into a high quality monitor without affecting normal usage. Complete kit with full instructions.

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Circle 177 on inquiry card.

Circle 178 on inquiry card.

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4001	.22	4024	.75	4069	.45	74C93	.95
4002	.22	4025	.22	4071	.20	74C151	1.75
4007	.27	4027	.45	4072	.35	74C157	1.75
4009	.45	4028	.80	4081	.22	74C160	1.20
4010	.45	4029	.95	4516	1.00	74C161	1.15
4011	.22	4030	.35	4518	1.20	74C163	1.00
4012	.22	4035	.97	4520	1.00	74C165	1.25
4013	.40	4042	.85	74C00	.27	74C173	1.30
4014	1.20	4044	.85	74C02	.27	74C174	1.20
4015	1.00	4045	.45	74C08	.30	74C175	1.20
4016	.45	4046	1.95	74C10	.27	74C192	1.30
4017	1.05	4049	.75	74C14	1.20	74C193	1.40
4018	.90	4050	.45	74C20	.27	74C901	.50
4019	.45	4052	1.00	74C42	.90	74C902	.50
4020	1.10	4051	1.10	74C73	.75	74C914	1.90
4021	1.10	4053	1.10	74C74	.50		
4022	1.00	4055	1.25	74C83	1.30		
4023	.22	4066	.70	74C86	.50		

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2518 HEX 32 BIT SR –	2.20	82S129 –	3.25
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4.000 MHz 8.000 MHz
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5.000 MHz 20.000 MHz
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100	.06	.14	.35	.90	3.70	5.00
200	.07	.20	.40	1.30	4.25	6.50
400	.09	.25	.65	1.50	6.50	9.50
600	.11	.30	.80	2.00	8.50	12.50
800	.15	.35	1.00	2.50	10.50	16.50
1000	.20	.45	1.25	3.00	12.50	20.00

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7402	.17	7473	.35	74160	.85
7403	.17	7474	.42	74161	.80
7404	.24	7475	.49	74162	1.20
7405	.24	7476	.45	74163	.82
7406	.33	7480	.45	74164	.85
7408	.27	7483	.60	74165	.85
7409	.24	7485	.75	74170	1.60
7410	.17	7486	.42	74173	1.30
7411	.22	7489	1.60	74174	.85
7412	.22	7490	.50	74175	.75
7413	.42	7491	.55	74176	.75
7414	.90	7492	.50	74177	.75
7416	.33	7493	.50	74180	.75
7417	.37	7494	.60	74181	1.90
7420	.17	7495	.60	74190	1.20
7425	.35	7496	.60	74191	1.20
7426	.33	74107	.35	74192	.79
7427	.35	74121	.35	74193	.79
7430	.17	74122	.39	74194	.85
7432	.27	74123	.42	74195	.65
7437	.27	74125	.45	74196	.85
7438	.27	74126	.45	74197	.85
7440	.17	74145	.75	74279	.75
7441	.85	74148	1.10	74368	.65
7442	.50	74150	1.10	74325	2.25
7445	.70	74151	.65	75491	1.05
7447	.60	74153	.55	75492	1.05
7448	.75	75154	1.10	8797	1.25
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74LS04 — .35	74LS160 — 1.10
74LS05 — .35	74LS162 — 1.10
74LS08 — .35	74LS163 — 1.20
74LS09 — .35	74LS164 — 1.20
74LS10 — .30	74LS168 — 1.25
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74LS13 — .95	74LS173 — 1.30
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74LS22 — .35	74LS191 — 1.15
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74LS27 — .45	74LS193 — 1.10
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74LS30 — .35	74LS196 — 1.20
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74LS54 — .35	74LS251 — 1.29
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74LS74 — 1.05	74LS258 — 1.50
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74LS90 — .90	74LS279 — .70
74LS92 — .90	74LS290 — .80
74LS93 — .90	74LS293 — .80
74LS107 — .45	74LS295 — 1.50
74LS109 — .45	74LS298 — 1.50
74LS112 — .45	74LS365 — .80
74LS113 — .45	74LS366 — .80
74LS114 — .55	74LS367 — .80
74LS125 — .90	74LS368 — .80
74LS126 — .90	74LS273 — 1.95
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LM311 — .75
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LM377 — 1.60
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1458 — .50
3900 — .85
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200	.80	1.30	2.10
400	1.30	1.90	3.10
600	2.00	2.75	4.30

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1.5A	6A	35A
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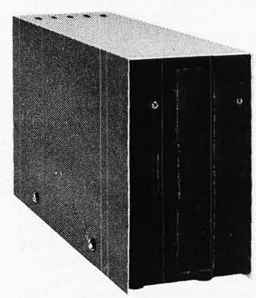
ITEM	REG. PRICE	OUR PRICE
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Centronics 779 Printer	$1599.00	$1175.00
Centronics 101 Printer	$1595.00	$1400.00
Anadex DP-8000 Printer	$1295.00	$ 995.00
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Verbatim Diskettes ea.	$ 5.95	$ 4.95
3	$ 17.89	$ 12.00
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Moonshadow Text Formatter for UCSD Pascal™ Systems

The UCSD Pascal™ system contains a screen-oriented text editor which is convenient, but which is not suited to word processing. It cannot underline, paginate automatically, or perform other essential text-processing functions. The **Moonshadow Text Formatter** (MTF) from Merrimack Systems solves this problem.

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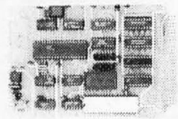
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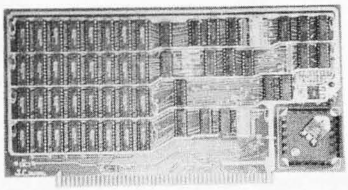
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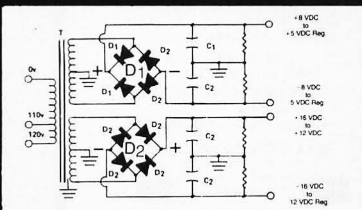
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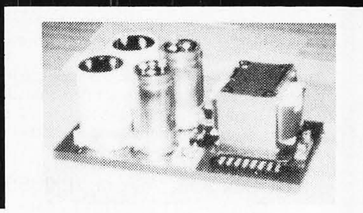
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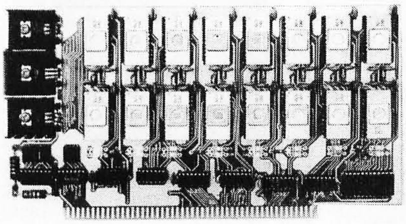
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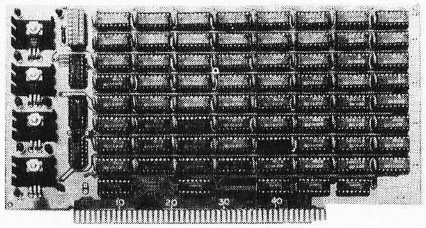
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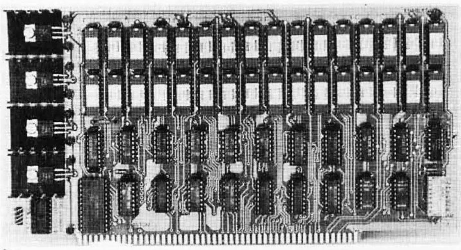
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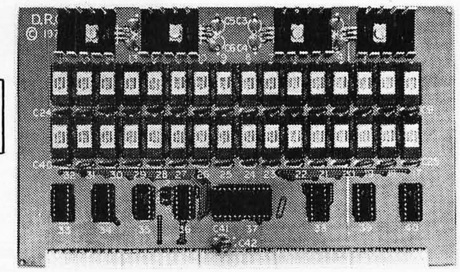
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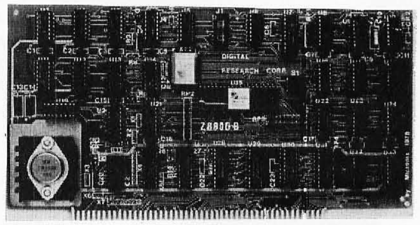
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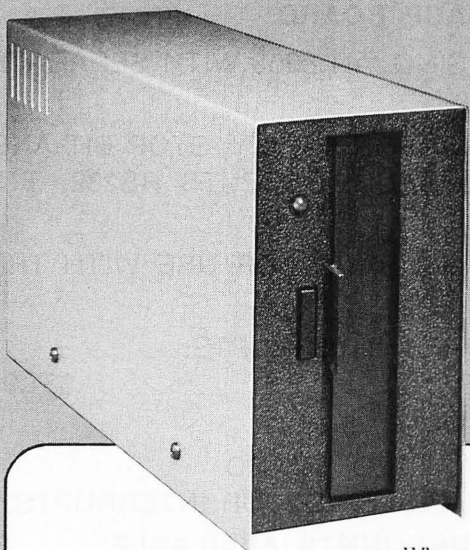
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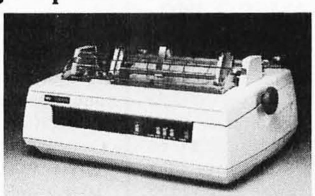
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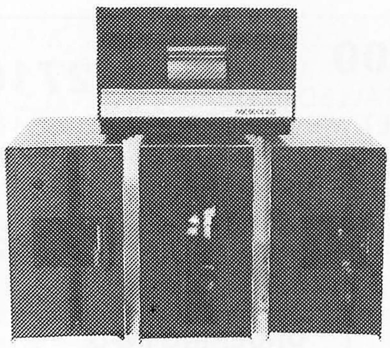
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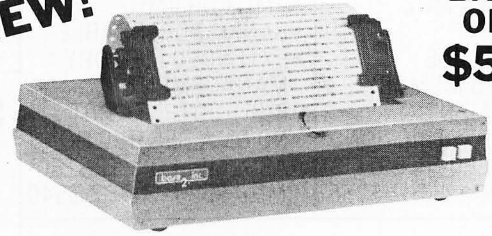
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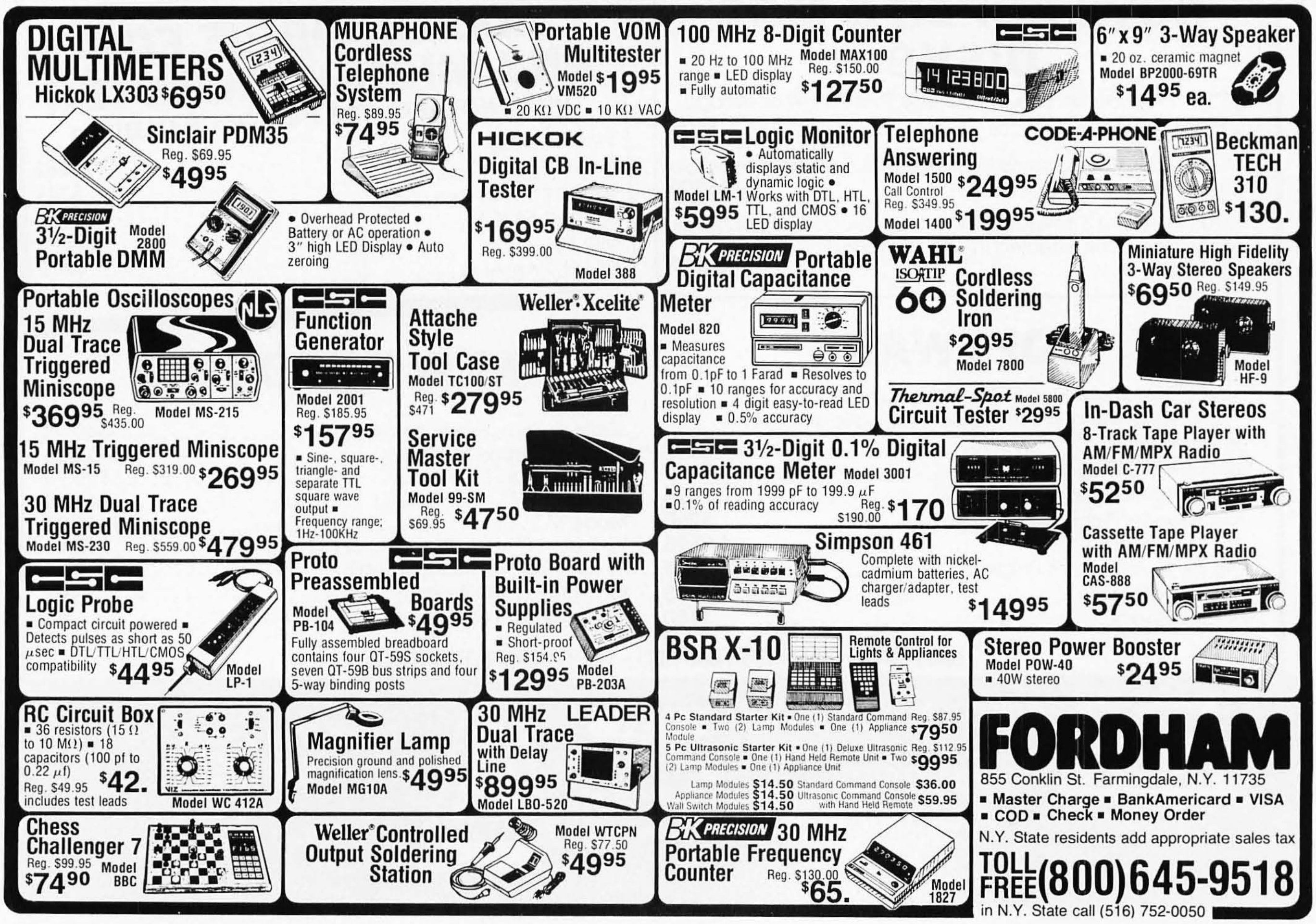
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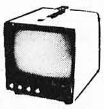
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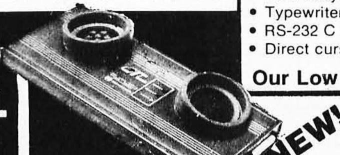
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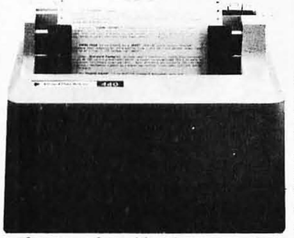
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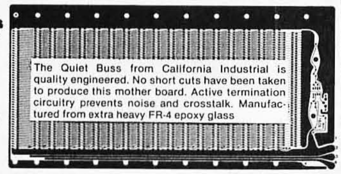
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Minidisk Drive for TRS-80

your choice **Lobo** or **Vista**

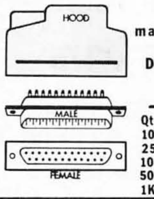
$388. Includes Interface Cable

FREE

PLASTIC LIBRARY CASE with purchase of each box of .... Verbatim mini-diskettes. $5 value.

$24.95 BOX of 10 **DISKETTES**

CONNECTORS



your choice
DB25P male plug & hood
or
DB25S female

$3.25

Qty.	fe.	male	hd.
10	3.05	1.95	1.15
25	2.95	1.79	1.05
100	2.65	1.67	.95
500	2.25	1.60	.85
1K	1.97	1.37	.73

Edge Connectors



GOLD 100 PIN IMSAI/ALTAIR

Imsai solder .125x.250	$2.95	3/$ 7.50
Imsai w/w .125centers	$4.95	3/$13.00
Altair soldertail .140 row	$5.95	3/$15.00
SPECIALS		
22/44 Kim eyelet.156"	$1.95	3/$5.00
25/50 solder tab .156"	$1.09	3/$2.00
36/72 wide post w/w.156	$1.95	3/$5.00

SYSTEM X·10



It's not offen that California Digital ventures into the distribution of consumer products, but we have resently come accross a product that appears so unique that we just had to add it to our product line. This is the System X-10 manufactured by the BSR turntable company. This space age system will remotely control any light or appliance in your home or office. Command signals are transmitted from the command console over your existing wiring. From your bed or easy chair you can control up to 16 different electrical devices inside and outside your home. Use the System X-10 to control your stereo, television or any light fixture on the premises.

The modular system is available in the following components:

Ultrasonic Master Control Console	$34.95
Battery Operated Ultrasonic Controller	19.95
Appliance Module, Lamp Module or Wall Switch	13.95

SPECiAL

APPLE II 16K MEMORY

COLOR • GRAPHICS • SOUND

$988 Mfg.Sug. Retail.... $1195

PLUS SHIPPING

Authorized Distributor Scotch® Data Products



		10 Pak	50+
740-0	IBM soft format.	$39.00	$3.50
740/2	Double side soft	65.00	6.00
741-0	Double density	53.00	4.90
743-0	Double/Double	70.00	6.60
740-32	8" Hard sector	39.00	3.50
744-(0)(10)(16)	5 1/4"mini	39.00	3.50
Library case for any above;		Add $3.00	
834 A	Data Cassette	5.50	
DC100	Mini Cartridge	16.00	
DC300	Data Cartridge	20.00	
920( )	Disk Cartridge	89.00	

Shugart Associates

SA800-R Floppy Disk Drive

The most cost effective way to store data processing information, when random recall is a prime factor. The SA800 is fully compatible with the IBM 3740 format. Write protect circuitry, low maintenance & Shugart quality.

$449.50

$85 KEYBOARD ASCII ENCODED



KEYTRONIC ASCII & ASCII complement.
*Ten key data pad
*Cursor controls
*Six user switches
* Alpha Lock
*Auto repeat
*Single 5 volt.
*Glass reed.

NEW

MEMORY

TRS-80 APPLE II $65
16k memory (8) 4116's

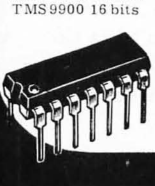


Installation is simple. Anyone who has ever changed a spark plug should be able to up-grade his microcomputer.
How can California Digital offer these memory up-grade sets at 25% below our competition? Simple, we buy in volume, wholesale to dealers and sell the balance directly to owners of personal microsystems. These 16K dynamic memory circuits are factory prime and unconditionally guaranteed for one full year. NOW, before you change your mind, pick up the telephone and order your up-grade memory from California Digital. Add $3 for TRS80 jumpers.

STATIC	1-31	32-99	100-5C	-999	1K+
21L02 450nS.	1.19	.99	.95	.90	.85
21L02 250nS.	1.49	1.39	1.25	*	*
2114 1Kx4 450	5.95	5.50	5.25	4.75	4.50
2114 1Kx4 300	8.95	8.50	8.00	*	*
4044 4Kx1 450	5.95	5.50	5.25	*	*
4044 4Kx1 250	9.95	9.50	9.00	*	*
4045 1Kx4 450	8.95	8.50	8.00	*	*
4045 1Kx4 250	9.95	9.50	9.00	*	*
5257 low pow.	5.95	5.50	5.00	4.80	4.60

SPECIAL CIRCUITS

Z80A 4 MHz.	24.95	AY5-1013A UART	4.95
8080A CPU	9.95	Floppy Disc Controllers	
8085	22.50	WD 1771 single D.	39.95
8086 Intel 16 bits	85.00	WD 1781 Double D	65.00
TMS9900 16 bits	49.95	WD 1791 D/D 3740	*



EPROMS		1-15	16-63	64+
1702A	2K	4.95	4.50	4.00
2708	8K	9.95	9.50	9.00
2716 5v	16K	39.95	35.00	*
2716 TI		24.88	20.00	*
2532		85.00	*	*



Regent® 25

Through years of research the ADDS Corporation has evolved a low maintenance, extremely durable CRT terminal capable of withstanding an abusive 24 hour duty cycle. The Regent 25 features Intel 8085 microprocessor controlled circuitry along with the Cherry Switch long-life capacitance keyboard.

18 key cursor and numeric pad doubles to allow for user definable special functions. True descending lower case characters along with a fully addressable cursor makes the Regent 25 the ideal word processing terminal.

High-resolution screen is capable of displaying 96 upper and lower case ASCII characters and 32 control codes. This terminal is switch selectable to display six European languages.

At $850 (plus shipping) the Regent 25 offers the best value in todays CRT terminal market. Additional data upon request.

The Imagination Machine by APF

A BRILLIANT COMPUTER WHOSE TIME HAS COME. **$495**



The IMAGINATION MACHINE is brilliant in concept, design and engineering. It's really two great achievements in one single package—a powerful state-of-the-art personal computer, and a thrilling, sophisticated home entertainment center that features electrifying mind-boggling games of skill, chance, dexterity and challenging multi-player competition.

As a computer, the Imagination Machine will be used for personal and family self-improvement, education, home management and finance. Specific application areas are limitless because the Imagination Machine is USER PROGRAMMABLE. This means that after a few hours of self-teaching, you will be able to begin communicating with the computer in the most popular language, BASIC. But if you never want to program it yourself, that's O.K., because APF has developed programming support that soon will become the standard of the industry.

For instance, as a tutor the Imagination Machine computer is without parallel. APF Tutor Programs make the quest for knowledge an adventure. In learning math, typing and music for example, the Imagination Machine will enable you to develop learning skills at a unique pace through a special interaction feedback network that automatically and instantly personalizes the computer to your particular learning speed. APF has finally accomplished what everyone else has been trying to do, control the power of the computer in order that it may be directed to help people at the personal level. The computer actually adjusts itself to your individual speed. Thus, with any of the countless special APF education programs available today and in the future, you can be spontaneously nourished and paced by what you have already learned from the Imagination Machine as you go forward, learning at an ever increasing pace.

SPECIFICATIONS

- RAM (Random Access Memory): 9,000 Bytes
- ROM (Read Only Memory): 10,000 Bytes
- Keyboard:
  - 53 key stepped typewriter-style keyboard, 2 game-style handheld controllers each with joysticks and 10 numeric keypads.
- Screen Format:
  - 32 characters x 16 lines (512 total). Alpha Numerics in 3 color modes.
  - Base Resolution Graphics—64x32 with up to 8 colors intermixed with Alpha Numeric characters.
  - High Resolution Graphics—Mode #1—128x192 in 8 colors. Mode #2—256x192 in 1 color.
- Connection to Home TV
- Tape Deck:
  - Quality built-in cassette tape deck with 6 functions (Record Audio, Playback Audio, Rewind, Fast-Forward, Stop, Eject).
  - Uses standard Phillips-type cassettes.
  - Speaker, Volume Control and Microphone Jack built-in
  - 3 Digit tape counter

Tape Deck (Cont.)
  - Digital track over 1200 Bits per second (1,200 Baud Rate).
  - Computer controlled motor.
- Built-In Sound Synthesizer:
  - Music Synthesizer with 3 full octaves including sharps and flats.
  - Special effects capability.
- Programmable in BASIC with unique Error Commentary System
- Additional Features:
  - Built-in RF Modulator for use with TV.
  - Unique entry system of BASIC command words.
  - Software available on cassette tapes and ROM cartridges.
- Future Expansion:
  - Additional 32K RAM memory.
  - Serial Port with Baud Rate 110 to 9600.
  - High and low speed hard copy Printers.
  - Mini-Floppy Disks (up to 4).
  - Telephone modem and Acoustic Couper.
  - AC Controller.

MINIATURE SWITCHES



your choice

$.98	10	50	100	1k
	$.88	.81	.73	.66

SPDT Miniature Toggles

7101 C&K	ON-NONE-ON
7107 jbt	ON-OFF(mnt.ON)
7108 CK	ON-(moment ON)
7103 CK	ON OFF ON
Rotary	3P-4-Pos.
Rotary	3P-6-Pos.
Push B (N.O.)	$.39ea. 4/$1

DIP Switch

$1.29 ea.	10	25	100	1K
	$1.19	1.09	.97	.83

specify 4 7 or 8 pos.



SPST



$139.50

PORTABLE DATA ENTRY SYSTEM

These used data terminals were originally designed for chain store inventory control and order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered into the recorder, the main warehouse is telephoned, the handset is placed in the acoustic coupler and all the recorded information is transmitted back to the master computer. With a little imagination and one of these portable entry systems, you should be able to exchange programs and computer information with associates across the country. All units were removed from service in working condition. Original cost $2,500.
Each system comes complete with:

- Portable Cassette Drive Unit
- Removable Entry Keyboard with LED Display
- Five Gould "D" NiCads
- Acoustical Coupler
- Battery Charger
- DB25 Cable
- Shoulder starp
- Full Documentation

DISCOUNT Wire Wrap Center

IC SOCKETS

pin	wire wrap ea.	25	50	low profile ea.	25	50
8	—	—	—	17¢	16	15
14	37¢	36	35	18	17	16
16	38	37	36	19	18	17
24	99	93	85	36	35	34
40	169	155	139	63	60	58

KYNAR WIRE WRAP 50ft. $.98

500	1,000	11,000
$9.	$15.	$105.



Battery wire wrapping tool $34.95

$29.95 BW630

OK HOBBY WRAP-30 wire wrap & strip tool $5.45

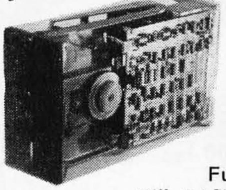
(213) 679-9001

All merchandise sold by California Digital is premium grade. Sorry, no COD's. Orders are shipped the same day received. California residents add 6%. Foreign orders add 10%. Orders over $25, when accompanied by payment, are shipped at our expense. Otherwise, please add $2.

VISA · master charge

Circle 204 on inquiry card.

FLOPPY SYSTEMS



8" Siemens FDD120-8D All Siemens options included in this drive may be configured hard or soft and single or double density. We find this to be an extremely reliable drive. **$430.00**
Fully Shugart compatible.



5¼" BASF Magical Miniature Mini drive only 2/3 the size of others is reliable and durable and quickly gaining in popularity with our customers. Single or dual density fast access times **$259.00**



Tarbell Controller may be re-configured to control 5¼" drives and includes short cable for one drive. **KIT $179.00, ASM $265,** but only$219 with purch. of 2 drives.

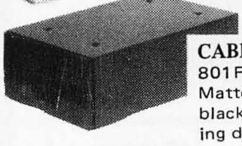


Cable Kits For 8" Drives with 10' 50 cond. cable and connectors. Also power cable and connectors. Flat cable assem if you wish. For one drive 27.50, two 33.95, three 38.95

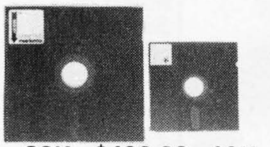
Cable Kits for 5¼" Drives as above, but 34 cond. For one drive **24.95**, two **29.95**.



"Power One" Model CP206 Power Supply adequate for at least two drives. 2.8A/24V 2.5A/5V, 0.5A/-5V beautiful quality. **$99.00**



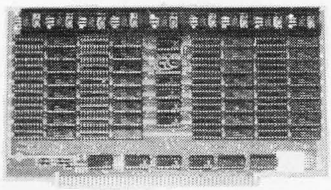
CABINETS for FDD120 and 801R drives, or CP206 supply. Matte finish in mar resistant black epoxy paint and stacking design **29.95**



DISKETTES (3M, MRX, BASF, Georgia Magnetics, & Victor Borge)
8" $39.95/10
5¼" $29.95/10

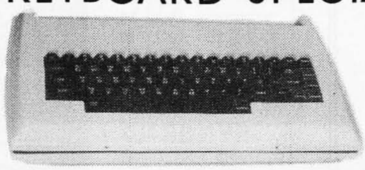
32K - $490.00 16K - $290.00

NEW!! – CHRISLIN 64K Dynamic RAM $750.00
(Showing Amazing Similarity to Tarbell's unit)
(16K Shown in photo)

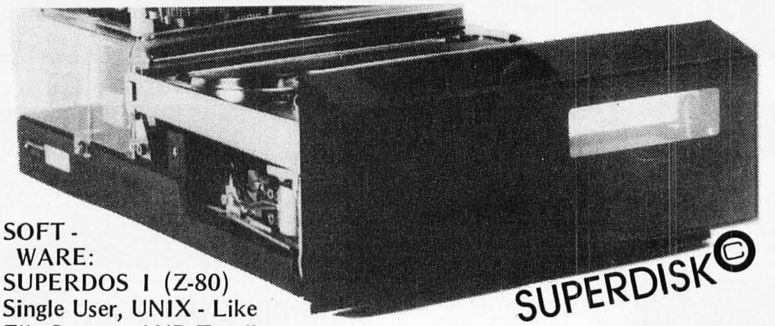


32K - $549.00 16K - $349.00

"BACK TO SCHOOL" KEYBOARD SPECIAL



CHERRY "PRO" Keyboard $119.00
Streamlined Custom Enclosure $34.95
BOTH ONLY $124.95 !!!!!!!!



10MBy DRIVE $3300

S-100 DMA CONTROL

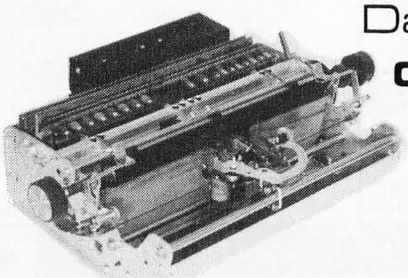
POWER UNIT $395.00

SOFT-WARE:
SUPERDOS I (Z-80)
Single User, UNIX - Like File System, AND Totally Upward Compatable From "XX/X"
(What did you say, Digital Research??)

PS: SUPERDOS-I runs on the TRS-80, and can transform it from a toy computer to a real business machine !!!

For the first time in something like 10 years, a new STANDARD in removable media has evolved. Selected by Datapoint, and others who have not yet announced, this drive is beautifully simple and easy, if not trivial to maintain. 920kBy/sec. transfer rate, 3600 RPM 39 lbs and only 125 Watts.

Daisy Wheel Printers



Qume Sprint 3\45

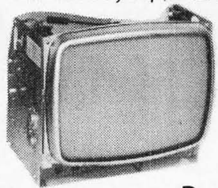
PRINTER (factory warr.) $1199.00
POWER SUPPLY (Boschert) $349.00
(shown mounted on rear of printer)

COMBINATION SPECIAL $1699.00

DATA DISPLAY MONITORS

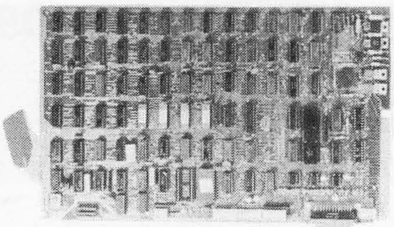
Used 12" Sylvania monitors. Composite Video, 15 MHz, 120VAC. Rebuilt with NEW P39 anti-glare tube $119.00 New P4, 109.00, used P4 79.00. U-fix model, 10/$300.00





"OEM STYLE" as above, will fit any case. (Both versions serviced by qualified tech). Identical to above but subtract $12.00

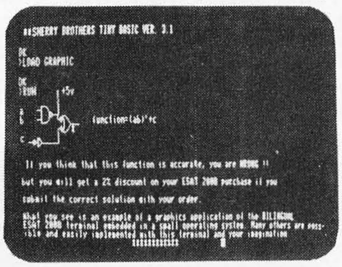
Electrolabs
POB 6721, Stanford, CA 94305
415-321-5601 800-227-8266
Telex: 345567 (Electrolab Pla)
Visa MC Am. Exp.



ESAT 200B

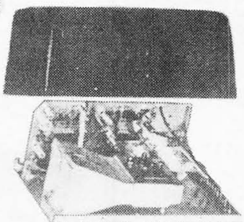
BI-LINGUAL 80x24 COMMUNICATING TERMINAL

Scrolling, full cursor, bell, 8x8 matrix, 110 - 19,200 baud, Dual Font Applications. Arabic & Hebrew, Multilingual Data Entry Forms Drawing, Music, & Switchyards. **$349.00**



New!

Doppler Motion Sensor Intrusion Detector



Extremely effective microwave motion detector for detecting unwanted visitors. Ignores mice and other non-larcenous creatures. Operates on 12VDC or from small transformer supplied. Output is relay closure for alarm control interface, or to switch on lights annunciators. Will operate THROUGH door of closet or thin wall. Best application seems to be to turn on outside lights to help invited guests, and to intimidate unwanted ones. **$159.00**
Water Repellent Cover $24.95

SOCKET SPECIAL



"Won't Let Go"

Low Profile

Solder Tail

1 CENT/ Pin !! (0.75/1000's)

8 14 16 18 20 22 24 28 40

CP/M* Source Code -- FREE! *when you purchase* "OS-1"

Electrolabs' new operating system for the Z-80 designed to have exactly the appearance of UNIX, including virtual I/O, "set TTY", a tree and a shell, filters and pipes PLUS total compatability with CP/M software!**

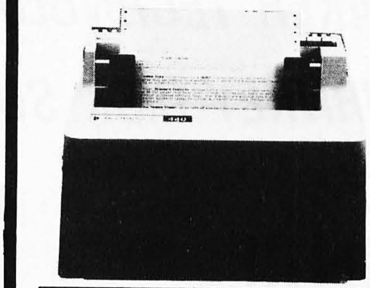
OS-1© FEATURES

(Because OS-1 is truly a comprehensive "OS", and not merely a file handling "DOS", we have changed the name from "Superdos" to "OS-1")

VIRTUAL I/O - copy with a single command between floppy and hard disk, or from TTY to printer to tape to disk... etc., etc. No messy I/O routines to write, & no awkward transfers.
SECURITY - 9 modes of file protection, user and login protection.
MULTI-USER - up to 256 passwords. (non-simultaneous users)
16MBy FILE SIZE - but no limit to no. of directories per device, thus allowing EASY implementation of gigantic storage devices.
"SET TTY" - for printer or crt: tabs, page width, buffer, cursor, UC/LC, fonts, formfeed, arbitrary control characters etc., etc.
"LOGIN" - automatically executes user selected programs and "set TTY".
OCCUPIES 12KBy - only 50% larger than CP/M, but 500% more features.
CP/M & CDOS COMPATABLE - your library is guaranteed to run!

*(Naturally, we are not giving away the version of CP/M written by Digital Research, Please pardon our pun, but they might object. What we ARE giving you is a greatly enhanced version of CP/M which resides on OS-1, and allows the user of OS-1 to run any and all of his programs, packages or system utilities which are already running on CP/M. We give you the source code at no charge so that you may modify any part of the CP/M to suit your own system requirements. At no charge, you also receive the enhancement allowing 4MBy files instead of 256K.)

OS-1 (with debugger, linker and screen oriented editor	$199.00
Update service, per year	29.00
Symbolic Debugger	150.00
MACRO-Assembler (Creates relocatable code)	150.00
"C" Compiler	660.00
FORTRAN Compiler	100.00
BASIC Compiler (very fast)	350.00



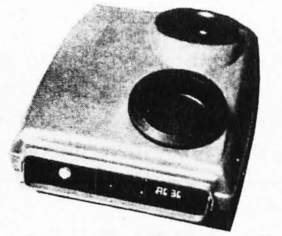
PAPER TIGER

IDS MODEL 440

- 8 Software Selectable Character Sizes
- Parallel & Serial Interface
- 98 ASCII Character set, upper & Lower case
- Forms length control
- Tractor Feed $995.00

Graphics option with 2K CRT screen buffer add $199.00

DYNAMIC DEVICES MODEM



- Acoustically coupled modem assembly set
- Asynchrous 0-300 Baud
- Switchable originate or answer modes
- Operates full or half duplex mode
- 15 minute assembly $149.95

NEW YEAR'S IC SPECTACULAR

(While Supply Lasts)

MEMORY & EPROM

2114	$ 3.00
2114-2	6.99
Pd411	2.50
2107 (pull outs)	2.00
7001 (pull outs)	2.00
4116 (set of 8, 16K)	69.00
5204	4.95
2708	8.95
2516	35.00
2716	35.00
TMS2716	19.00
2732	95.00

CPU

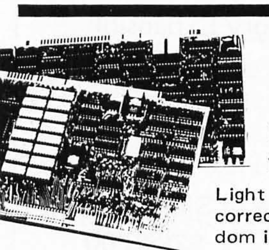
1802CD	$19.95
6502	6.25
Z-80	9.95
Z-80A	12.95
8080A	8.99
8085	22.00
8741	79.00

FLOPPY CONTROLLERS

1771	$26.95
1791	37.95
Pd372	39.00

MISCELLANEOUS (CALL US!!)

ELECTROLABS
POB 6721 Stanford, CA 94305
415-321-5601 800-227-8266
Telex: 345567 (Electrolab Pla)



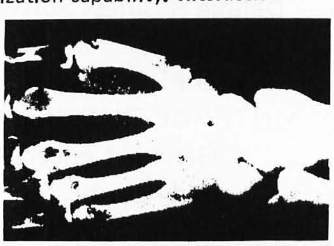
Graphics

High Resolution 480 x 512
for B&W and Color Imaging and Graphics

Light pen, A-D, D-A, TV synchro (needs no time base correction or adjustment with anything between random interface & NTSC commercial standard). T.V. single frame grabber ("snapshot"). Up to 1 Byte of attributions per pixel.

LSI-100 & S-100 applied to:

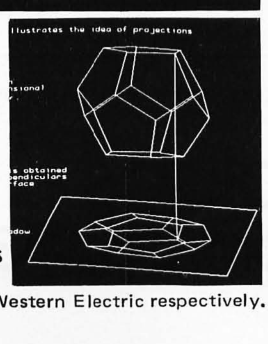
Graphic Presentation — such as computer generated animation & other graphic displays up to 256 colors & up to 256 b&w gray scales. **Image Analysis** — using built-in FRAME GRABBER, for medical image enhancement, contour analysis, & pattern recognition. **Commercial TV Tilting & Advertising** — using synchronization capability. **Interactive graphics** — using light pen accessory.



BASIC CONFIGURATION —
LSI-11 $1995. S-100 $1265.
For TRS-80/Exidy Add $595.00
Includes: Data Board - 32K (480 x 512 x 1 pixel) D-A 16 level video generator. Video Synchronization Circuitry. Address Control & Timing Board.

FEATURES — High speed. DMA or 2KBy window memory mapped interface. Full NTSC commercial color capability. Low power consumption. Excellent Software

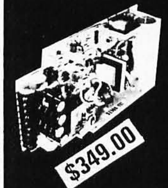
Options — Accessories — Software
Options include: light pen, auxilliary outputs, text mode, memory and much more. Accessories include: b&w and color cameras and monitors. Software: "Plot" 2D or 3D, "Tilting", "Contour", "Image Enhancement", "Vector Curve Generation".



Call for price and details

*CPM and **UNIX trademarks of Digital Research and Western Electric respectively.

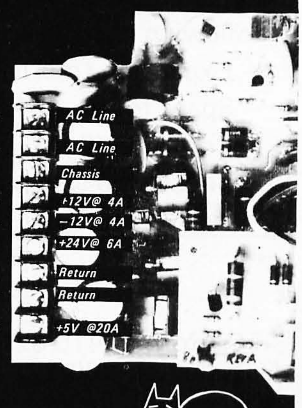
Electrolab's System Switcher Model SP04



Tames
RAW POWER
for the
LSI-11/23 ★
And Hard Disks



FEATURES:
*
Brown-Out Proof
Line Frequency Indifferent
Very Low EMI
U.L. Approved
20 KHz
High Efficiency
Soft Start
Extremely Lightweight
Open Frame Design
Short Circuit and OV Protection
20,000 Hour MTBF (MIL 217B)
Adaptable to Un-Interruptable Power applications.
and
Low Cost!! (just look at DEC's price)



ElectroLAbs

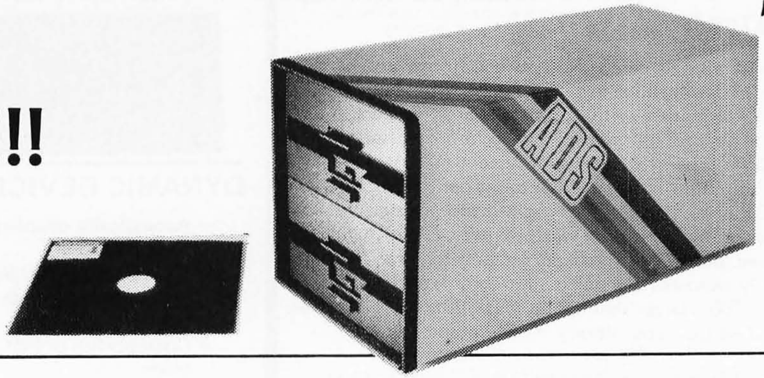


Circle 206 on inquiry card.

MATCHMAKER TECHNOLOGY
TURNKEY DISK SUBSYSTEMS

✓ SORCERER
✓ TRS-80
✓ APPLE
✓ HPIB
✓ PET

DISK IS IN!!!



For those who wish to avoid the aggravation, fussing, irritation, annoyance etc., of assembling your own subsystem, plug in and GO!!!

APPLE

FEATURES:

- 2 8" Floppy DISK DRIVES (Single Sided)
- Color Coordinated Cabinet with Power Supply
- Expanded version of APPLE-DOS
- Single Density Disk Controller
- Full Cabling, Connectors + Documentation
- Assembled and Tested
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TRS-80

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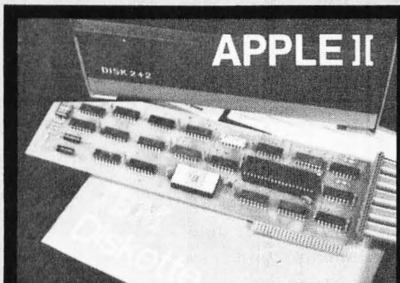
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SN7404N	.18	SN7479N	5.00	SN74164N	.89
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SN7429N	.39	SN74122N	.39	SN74191N	1.25
SN7430N	.20	SN74123N	.49	SN74192N	.79
SN7432N	.25	SN74125N	.49	SN74193N	.79
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CD4007	.25	CD4030	.49	CD4081	.23
CD4009	.49	CD4035	.99	CD4082	.23
CD4010	.49	CD4040	1.19	CD4093	.99
CD4011	.23	CD4041	1.25	CD4098	2.49
CD4012	.25	CD4042	.99	MC14409	14.95
CD4013	.39	CD4043	.89	MC14410	14.95
CD4014	1.39	CD4044	.89	MC14411	14.95
CD4015	1.19	CD4046	1.79	MC14419	4.95
CD4016	.49	CD4047	2.50	MC14433	19.95
CD4017	1.19	CD4048	1.35	MC14506	.75
CD4018	.99	CD4049	.49	MC14507	.99
CD4019	.49	CD4050	.49	MC14562	14.50
CD4020	1.19	CD4051	1.19	MC14583	3.50
CD4021	1.39	CD4053	1.19	CD4508	3.95
CD4022	1.19	CD4056	2.95	CD4510	1.39
CD4023	.23	CD4059	9.95	CD4511	1.29
CD4024	.79	CD4060	1.49	CD4515	2.95
CD4025	.23	CD4066	.79	CD4518	1.29
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74C08	.49	74C90	1.95	74C192	2.49
74C10	.39	74C93	1.95	74C193	2.49
74C14	1.95	74C95	1.95	74C195	2.49
74C20	.39	74C107	1.25	74C922	7.95
74C30	.39	74C151	2.90	74C923	6.25
74C42	1.95	74C154	3.00	74C925	8.95
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LM302H	.75	LM340T-5	1.25	LM739N	1.19
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LM305H	.60	LM340T-8	1.25	LM741-14N	.39
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LM308CN/H	1.00	LM340T-15	1.25	LM748N/H	.39
LM309H	1.10	LM340T-18	1.25	LM1310N	1.95
LM309K	1.25	LM340T-24	1.25	LM1458CN/H	.59
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LM320K-15	1.35	NE510A	6.00	LM3900N(3401)	.59
LM320K-18	1.35	NE529A	4.95	LM3905N	1.49
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LM320T-12	1.25	NE550N	1.30	75451CN	.39
LM320T-15	1.25	NE555V	.39	75452CN	.39
LM320T-18	1.25	NE556N	.99	75453CN	.39
LM320T-24	1.25	NE560B	5.00	75454CN	.39
LM323K-5	5.95	NE562B	5.00	75491CN	.79
LM324N	1.49	NE565N/H	1.25	75492CN	.89
LM339N	.99	NE566CN	1.75	75493N	.89
LM340K-5	1.35	NE567V/H	.99	75494CN	.89
LM340K-6	1.35	NE570N	4.95	RC4136	1.25
LM340K-8	1.35	LM703CN/H	.69	RC4151	3.95
LM340K-12	1.35	LM709N/H	.29	RC4194	4.95
LM340K-15	1.35			RC4195	4.49

74LS00TTL

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74LS01	.29			74LS139	.89
74LS02	.29	74LS47	.89	74LS151	.89
74LS03	.29	74LS51	.29	74LS155	.89
74LS04	.35	74LS54	.29	74LS157	.89
74LS05	.35	74LS55	.29	74LS160	1.15
74LS08	.29	74LS73	.45	74LS161	1.15
74LS09	.35	74LS74	.45	74LS162	1.25
74LS10	.29	74LS75	.59	74LS163	1.15
74LS11	.75	74LS76	.45	74LS164	1.25
74LS13	.59	74LS78	.49	74LS175	.99
74LS14	1.25	74LS83	.89	74LS181	2.49
74LS15	.35	74LS85	1.25	74LS190	1.15
74LS20	.29	74LS86	.45	74LS191	1.15
74LS21	.35	74LS90	.59	74LS192	1.15
74LS22	.35	74LS92	.75	74LS193	1.15
74LS26	.35	74LS93	.75	74LS194	1.15
74LS27	.35	74LS95	.99	74LS195	1.15
74LS28	.35	74LS96	1.15	74LS253	.99
74LS30	.29	74LS107	.45	74LS257	.89
74LS32	.35	74LS109	.45	74LS258	1.75
74LS37	.45	74LS112	.45	74LS260	.69
74LS40	.35	74LS123	1.25	74LS279	.75
74LS42	.89	74LS125	.89	74LS367	.75
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8K Bytesaver II

Memory Capacity: 8K bytes
Memory Type: 2708 PROM or equivalent
Memory Access Time: 450 nanoseconds
Wait States at 2MHz: none required
Wait States at 4MHz: one per machine cycle
Bus: S-100
Power Requirements: +8V @ 0.8A, +18V @ 0.4A, −18V @ 0.2A
Operating Environment: 0-55°C.

Cromemco's 8K BYTESAVER® card provides a built-in programmer for the popular 2708 PROM and has the capacity for a full 8K bytes of PROM memory storage. The BYTESAVER® II also offers a number of new features including convenient switch selection of board address and Cromemco's powerful memory bank selection. The BYTESAVER® II is assembled and tested (Model 8KBS-W) for $245.

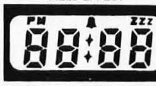
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XC556G	green	4/$1	XC209G	green	4/$1
XC556Y	yellow	4/$1	XC209Y	yellow	4/$1
XC556C	clear	4/$1			
.200" dia.			.185" dia.		
XC22R	red	5/$1	XC526R	red	5/$1
XC22G	green	4/$1	XC526G	green	4/$1
XC22Y	yellow	4/$1	XC526Y	yellow	4/$1
.170" dia.			XC526C	clear	4/$1
MV10B	red	4/$1	.190" dia.		
.085" dia.			XC111R	red	5/$1
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MAN 2	5 x 7 Dot Matrix-red	.300	4.95	MAN 6740	Common Cathode-red-D.D.	.560	.99
MAN 3	Common Cathode-red	.125	.25	MAN 6750	Common Cathode-red ± 1	.560	.99
MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	.300	.99
MAN 72	Common Anode-red	.300	.75	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.49	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.49	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	.630	1.49
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MAN 4640	Common Cathode-orange	.400	.99	DL33B	Common Cathode-red	.110	.35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.99
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	.500	.99
MAN 4840	Common Cathode-yellow	.400	.99	FND507	Common Anode (FND510)	.500	.99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	.99
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.800	1.50
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode red	.800	1.50
MAN 6650	Common Cathode-orange ± 1	.560	.99	5082-7300	4 x 7 sgl. Digit-RHDP	.600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl. Digit-LHDP	.600	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character (±1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	.600	22.50

RCA LINEAR

Part	Price	Part	Price
CA3013T	2.15	CA3082N	2.00
CA2023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	.85	CA3401N	.59
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Part	Price
MM5725	$2.95
MM5738	2.95
DM8864	2.00
DM8865	1.00
DM8887	.75
DM8889	.75
9374 7 seg. C.A. LED driver	1.50

CLOCK CHIPS

Part	Price
MM5309	$4.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
CT7001	6.95

MOTOROLA

Part	Price
MC1408L7	$4.95
MC1408L8	5.75
MC1439L	2.95
MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	$.17	.16	.15	22 pin LP	$ .37	.36	.35
14 pin LP	.20	.19	.18	24 pin LP	.38	.37	.36
16 pin LP	.22	.21	.20	28 pin LP	.45	.44	.43
18 pin LP	.29	.28	.27	36 pin LP	.60	.59	.58
20 pin LP	.34	.32	.30	40 pin LP	.63	.62	.61




SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100		1-24	25-49	50-100
14 pin ST	$.27	.25	.24	28 pin ST	$ .99	.90	.81
16 pin ST	.30	.27	.25	36 pin ST	1.39	1.26	1.15
18 pin ST	.35	.32	.30	40 pin ST	1.59	1.45	1.30
24 pin ST	.49	.45	.42				



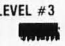

SOLDERTAIL STANDARD (GOLD)

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin SG	$.30	.27	.24	24 pin SG	$ .70	.63	.57
14 pin SG	.35	.32	.29	28 pin SG	1.10	1.00	.90
16 pin SG	.38	.35	.32	36 pin SG	1.65	1.40	1.26
18 pin SG	.52	.47	.43	40 pin SG	1.75	1.59	1.45




WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin WW	$.39	.38	.31	22 pin WW	$ .95	.85	.75
10 pin WW	.45	.41	.37	24 pin WW	1.05	.95	.85
14 pin WW	.39	.38	.37	28 pin WW	1.40	1.25	1.10
16 pin WW	.43	.42	.41	36 pin WW	1.59	1.45	1.30
18 pin WW	.75	.68	.62	40 pin WW	1.75	1.55	1.40
20 pin WW	.85	.79	.72				

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea.	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	50 PCS	$1.75
ASST. 2	5 ea.	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	50 PCS	1.75
ASST. 3	5 ea.	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	50 PCS	1.75
ASST. 4	5 ea.	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	50 PCS	1.75
ASST. 5	5 ea.	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	50 PCS	1.75
ASST. 6	5 ea.	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	50 PCS	1.75
ASST. 7	5 ea.	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

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AY-5-9200	Repertory Dialler	14.95
AY-5-9500	CMOS Clock Generator	4.95
AY-5-2376	Keyboard Encoder (88 keys)	14.95
HD0165	Keyboard Encoder (16 keys)	7.95
74C922	Keyboard Encoder (16 keys)	7.95
74C923	Keyboard Encoder (20 keys)	6.25

ICM CHIPS

ICM7045	CMOS Precision Timer	24.95
ICM7205	CMOS LED Stopwatch/Timer	19.95
ICM7207	Oscillator Controller	7.50
ICM7208	Seven Decade Counter	19.95
ICM7209	Clock Generator	6.95

NMOS READ ONLY MEMORIES

MCM6571	128 X 9 X 7 ASCII Shifted with Greek	13.50
MCM6574	128 X 9 X 7 Math Symbol & Pictures	13.50
MCM6575	128 X 9 X 7 Alpha Control Char Gen	13.50

MISCELLANEOUS

TL074CN	Quad Low Noise bi-fet Op Amp	2.49
TL494CN	Switching Regulator	4.49
TL496CP	Single Switching Regulator	1.75
11C90	Divide 10/11 Prescaler	19.95
95H90	Hi-Speed Divide 10/11 Prescaler	11.95
4N33	Photo-Darlington Opto-Isolator	3.95
MK50240	Top Octave Freq. Generator	17.50
DS0026CH	5Mhz 2-phase MOS clock driver	3.75
TIL308	.27" red num. display w/integ. logic chip	10.95
MM5320	TV Camera Sync. Generator	14.95
MM5330	4½ Digit DPM Logic Block (Special)	3.95
LD110/111	3½ Digit A/D Converter Set	25.00/set
MC14433P	3½ Digit A/D Converter	13.95

LITRONIX ISO-LIT 1
Photo Transistor Opto-Isolator
(Same as MCT 2 or 4N25)
49¢ each

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Generates Complex Sounds
Low Power - Programmable
$3.95 each

TV GAME CHIP AND CRYSTAL
AY-3-8500-1 and 2.01 MHZ Crystal (Chip & Crystal includes score display, 6 games and select angles, etc. **7.95/set**

EXAR

Part	Price	Part	Price	Part	Price
XR205	$8.40			XR2242CP	1.50
XR210	4.40			XR2264	4.25
XR215	4.40			XR2556	3.20
XR320	1.55			XR2567	2.99
XR-L555	1.50	JE2206KB	19.95	XR3403	1.25
XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	3.95
XR567CP	.99	XR2207	3.85	XR4194	4.95
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.95	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.95	XR2212	4.35	XR4739	1.15
XR1489	1.95	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
				1N4002	100 PIV	1 AMP	12/1.00
				1N4003	200 PIV	1 AMP	12/1.00
1N746	3.3	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N3600	50	200m	6/1.00
1N757	9.0	400m	4/1.00	1N4148	75	10m	15/1.00
1N759	12.0	400m	4/1.00	1N4154	35	10m	12/1.00
1N959	8.2	400m	4/1.00	1N4733	5.1	1w	28
1N965	15	400m	4/1.00	1N4734	5.6	1w	28
1N5232	5.6	500m	28	1N4735	6.2	1w	28
1N5234	6.2	500m	28	1N4736	6.8	1w	28
1N5235	6.8	500m	28	1N4738	8.2	1w	28
1N5236	7.5	500m	28	1N4742	12	1w	28
1N5242	12	500m	28	1N4744	15	1w	28
1N5245	15	500m	28	1N1183	50 PIV	35 AMP	1.60
1N456	25	40m	6/1.00	1N1184	100 PIV	35 AMP	1.70
1N458	150	7m	6/1.00	1N1185	150 PIV	35 AMP	1.70
1N485A	180	10m	5/1.00	1N1186	200 PIV	35 AMP	1.80
1N4001	50 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1.95
C36M	35A @ 600V	SCR	1.95
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

Part	Price	Part	Price	Part	Price
C106B1	.50			2N3904	4/1.00
MPSA05	.30	2N3055	.89	2N3905	4/1.00
MPSA06	5/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369A	4/1.00	MPS3705	5/1.00	2N5087	4/1.00
MPS2369	5/1.00	2N3706	5/1.00	2N5088	4/1.00
2N2484	4/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2906	4/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2907	5/1.00	2N3711	5/1.00	PN5134	5/1.00
PN2907 Plastic	7/1.00	2N3724A	.65	PN5138	5/1.00
2N2925	5/1.00	2N3725A	1.00	2N5139	5/1.00
MJE2955	1.25	2N3772	2.25	2N5210	5/1.00
2N3053	2/1.00	2N3823	1.00	2N5449	3/1.00
		2N3903	5/1.00	2N5951	3/1.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100+		1-9	10-99	100+
10 pf	.05	.04	.03	.001μF	.05	.04	.035
22 pf	.05	.04	.03	.0047μF	.05	.04	.035
47 pf	.05	.04	.03	.01μF	.05	.04	.035
100 pf	.05	.04	.03	.022μF	.06	.05	.04
220 pf	.05	.04	.03	.047μF	.06	.05	.04
470 pf	.05	.04	.035	.1μF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

	1-9	10-99	100+		1-9	10-99	100+
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

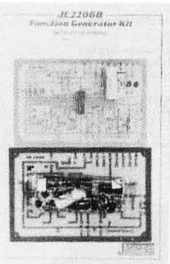
	1-9	10-99	100+		1-9	10-99	100+
.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/35V	.35	.31	.27
.22/35V	.28	.23	.17	3.3/25V	.35	.31	.27
.33/35V	.28	.23	.17	4.7/25V	.33	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.49	.45	.35
.68/35V	.28	.23	.17	15/25V	.75	.68	.59
1.0/35V	.28	.23	.17	22/6V	.75	.60	.50

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead	1-9	10-99	100+	Radial Lead	1-9	10-99	100+
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

Jim-pak® electronic components — Quality Kits

Function Generator Kit



Provides three basic waveforms: sine, triangle and square wave. Frequency range from 1 Hz to 100K Hz. Output amplitude from 0 volts to over 6 volts (peak to peak). Uses a 12V supply or a ±6V split supply. Includes chip, P.C. Board, components & instructions.

JE2206B $19.95

Digital Thermometer Kit



Dual sensors — switching control for indoor/outdoor or dual monitoring. Continuous LED .8" ht. display. Range: -40°F to 199°F / -40°C to 100°C. Accuracy ±1° nominal. Set for Fahrenheit or Celsius. Simulated walnut case. AC wall adapter included.
Size: 3¼"h x 6-5/8"w x 1-3/8"d.

JE300 .... $39.95

Digital Stopwatch Kit

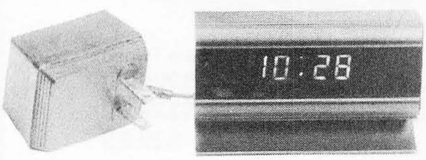


Use Intersil 7205 Chip. Plated thru double-sided P.C. Board. Red LED display. Times to 59 minutes, 59.59 seconds with auto reset. Quartz crystal controlled. Three stopwatches in one: single event, split (cummulative) and taylor (sequential timing). Uses 3 penlite batteries.

Size: 4.5" x 2.15" x .90"

JE900 .... $39.95

4-Digit Clock Kit



Bright .357" ht. red display. Sequential flashing colon. 12 or 24 hour operation. Black extruded aluminum case. Pressure switches for hours, minutes and hold functions. Includes all components, case and wall transformer. Size: 3¼" x 1¾" x 1¼"

JE730 .... $14.95

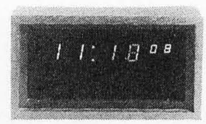
6-Digit Clock Kit



Bright .300 ht. common cathode display. Uses MM-5314 clock chip. Switches for hours, minutes and hold functions. Hours easily viewable to 20 ft. Simulated walnut case. 115VAC operation. 12 or 24 hour operation. Includes all components, case and wall transformer. Size: 6¾" x 3-1/8" x 1¾"

JE701 .... $19.95

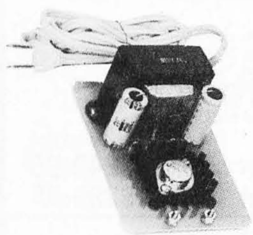
Jumbo 6-Digit Clock Kit



Four .630" ht. and two .300" ht. comm. anode displays. Uses MM5314 clock chip. Switches for hrs., mins., and hold functions. Hours viewable to 30 ft. Sim. walnut case. 115VAC operation. 12 or 24 hour operation. Incl. all components, case and wall transformer. Size: 6¾" x 3-1/8" x 1¾"

JE747 .... $29.95

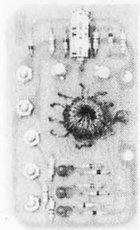
Regulated Power Supply Kit



Uses LM309K. Heat sink provided. PC board construction. Provides solid 1 amp @ 5 volts. Includes components, hardware & instructions. Size: 3½" x 5" x2"h

JE200 .... $14.95

Multi-Voltage Board Kit

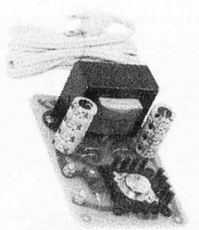


ADAPTS TO JE200
SUPPLIES ±5V, ±9V and ±12V

Independent load rating at single terminal. ±12V:160mA, ±9V:200 mA, –5V:250mA. DC/DC converter with +5V input. Toriodal hi-speed switching XMFR. Short circuit protection. PC board construction. Piggy-back to JE200 board. Size: 3½" x 2" x 9/16"h

JE205 .... $12.95

Variable Power Supply Kit



Full 1.5 amp @ 5-10V output. Up to .5 amp @ 15V output. Heavy duty transformer. Three-terminal I.C. voltage regulator. Heat sink provided for cooling efficiency. PC board construction. 120VAC input.
Size: 3½" x 5" x 2"h

JE210 .... $19.95

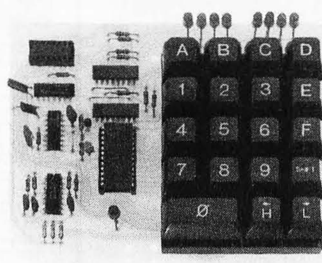
62-Key ASCII Encoded Keyboard Kit



The **JE610 ASCII KEYBOARD KIT** can be interfaced into most any computer system. The JE610 kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and –12V @ 10mA for operation. Features: 60 keys generate the full 128 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector.

JE610 .... $79.95

Hexadecimal Encoder Kit



FULL 8-BIT LATCHED OUTPUT — 19-KEY KEYBOARD

The **JE600 ENCODER KEYBOARD** provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three (3) additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation.

JE600 .... $59.95

(Prices Subject To Change)

Circle 218 on inquiry card.

SEE OUR 52 PAGE AD IN JANUARY BYTE

DISC DRIVES

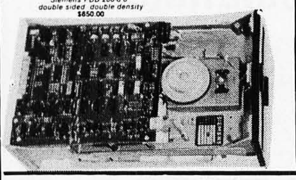
SHUGART SA 400 5¼"
110KB,35 tracks
SHUGART SA 400 **$295.00**

SHUGART SA 400
with attractive metal case with cutouts for Data Cable switch, fuse and power cord.
LOBO SA400-C **$325.00**

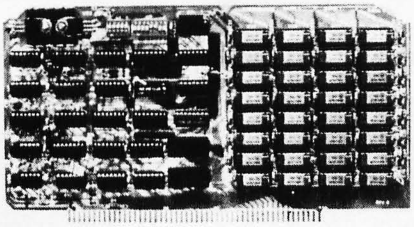
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with Cabinet and Power Supply Assembled, tested & Guaranteed
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SHUGART 801R 8"
6.4 megabits, single or double density, hard or soft sector, write protect, and more
SHUGART 801R **$495.00**

Siemens FDD 200-8 8"
double sided double density
$650.00



SD EXPANDORAM *The Ultimate S-100 Memory*



EXPANDO 64 KIT (4116):

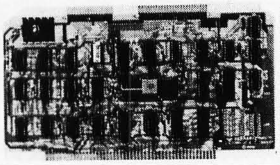
	List Price	Sale Price
16K	$385.00	$239.00
32K	$550.00	$309.00
48K	$715.00	$379.00
64K	$880.00	$449.00

The EXPANDORAM is available in versions from 16K up to 64K, so for a minimum investment you can have a memory system that will grow with your needs. This is a dynamic memory with the invisable on-board refresh, and IT WORKS!

- Interfaces with Altair, IMSAI, SOL-8, Cromenco, SBC-100, and others.
- Bank Selectable
- Phantom
- Power 8VDC, ± 16VDC, 5 Watts

Lowest Cost Per Bit
Uses Popular 4116 RAMS
PC Board is doubled solder masked and has silk-screen parts layout.

Extensive documentation clearly written
Complete Kit includes all Sockets for 64K
Memory access time: 375ns, Cycle time: 500ns.
No wait states required.
16K boundries and Protection via Dip Switches
Designed to work with Z-80, 8080, 8050 CPU's



FEATURES: IBM 3740 Soft Sectored Compatible. S-100 BUS Compatible for Z-80 or 8080. Controls up to 4 Drives (single or double sided). Directly controls the following drives:
1. Shugart SA400/450 Mini Floppy.
2. Shugart SA800/850 Standard Floppy.
3. PERSCI 70 and 277.
4. MFE 700/750.
5. CDC 9404/9406.
6. GSI/Siemans FDD120-8.

34 Pin Connector for Mini Floppy. 50 Pin Connector for Standard Floppy. Operates with modified CP/M operating system and C-Basic Computer. The new "Versafloppy" from S.D. Computer Products provides complete control for many of the available Floppy Disk Drives. Both Mini and Full Size. FD1771B-1 Single Density Controller Chip. Listings for Control Software are included in price.
CPM for SD Versafloppy $100.00

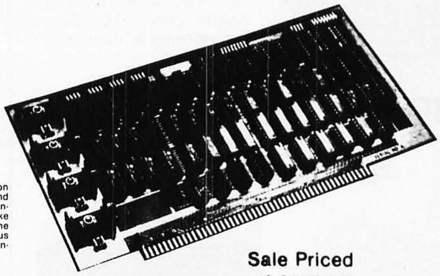
DISC CONTROLLER SD "VERSAFLOPPY" KIT

The Versatile Floppy Disk Controller

List Price **$250.00**

SALE PRICE $189.95

SHOP & COMPARE SPECIAL



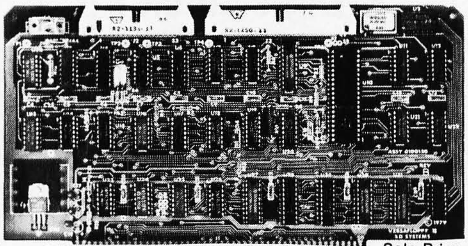
M-XVI
The true 16K Static Ram module for S-100 bus systems.
ASSEMBLED & TESTED -- 100% BURN IN

The M-XVI gives you unbelievable expansion capability for your S-100 bus system -even beyond 64K. Manufactured to the highest industry standards documented and designed to make assembly, use, and programming a snap. The M-XVI board is a true revelation for the serious hobbyist and use in practical business or industrial applications.

FEATURES:
- Fully static
- Uses popular 2114 static RAMS
- +5 volt operation only
- Bank Select available by bank port and bank byte
- Phantom line capability
- Addressable in 4K blocks
- 4K blocks can be addressed any where within 64K in 4k increments
- Meets IEEE proposed S-100 signal standards
- LED indicators for board selection and bank selection
- FR-4 epoxy PC boards
- Solder masked on both sides
- Silk screen of part number and part designator

		Sale Priced
2016BA 450ns 2MHZ	Reg.$349.95	$295.00
2016BB 300ns 4MHZ	Reg.$389.95	$329.00
2016BY Bare Board only		$29.95

VERSAFLOPPY II
DOUBLE DENSITY, DOUBLE SIDED, DISC.CONTROLLER

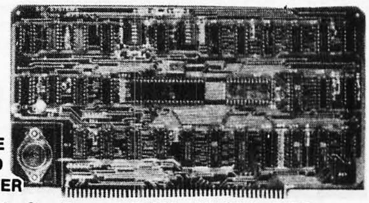


SDS-VERSAFLOPPY II KIT List Price **$350.00** Sale Price **$325.95**

GENERAL DESCRIPTION:
Versafloppy II is a flexible disk drive controller that incorporates a wide range of capabilities into one board. It operates with double density soft sectored format which provides 985,600 bytes of storage on a double sided 8 inch diskette and 129,920 bytes per side on a five inch mini-diskette. The Versafloppy II directly controls many popular disk drives. These include: Shugart SA400 and SA450; Shugart SA800 and SA850; Mayflower MFE500 and MFE700; Per Sci 70 and 277; and Siemans, BSI-105.

- S-100 Bus IEEE Standard Compatible
- IBM-3740 Compatible Soft Sectored Format for Single Density Drives
- Operates with both Standard (8") and Mini (5") Drives Simultaneously
- Provides Control for Double Sided Operation
- Operates with Z80, 8080, and 8085 Central Processing Unit
- Controls up to four drives
- Vectored Interrupt Operation Optional
- Control and Diagnostic Software Available in PROM
- SDOS Disk Operating System Compatible

SINGLE BOARD COMPUTER



With On-Board RAM, PROM, CTC
- S-100 Bus Compatible
- Z80 Central Processing Unit
- 1024 Bytes of Random Access Memory
- 8K Bytes of PROM using 2716
- Parallel Input and Output Ports
- Four Channel Counter/Timer (Z80-CTC)
- Software Programmable Baud Rate Generator
- No Front Panel Required for Operation

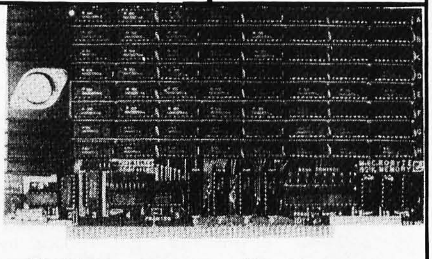
	List Price	Sale Price
SDS-SBC-100 2MHZ KIT	$295.00	$249.95
SDS-SBC-200 4MHZ KIT	$320.00	$289.95

THE MICROBYTE M32KSS 32K STATIC MEMORY BOARD ASSEMBLED & TESTED *

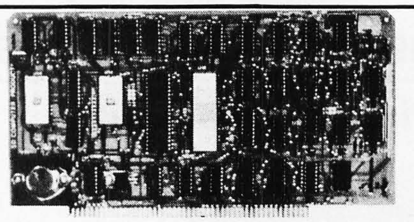
SAVE $120.00

• Fully S100 Bus Compatible, IMSAI, SOL, ALTAIR, ALPHA MICRO. • Uses National's Low Power 5257 4K x 1 Static Rams. • 2 MHz or 4MHz operation. • Gold contacts for higher reliability. • On board single 5 amp regulator. • On board single 5 amp regulator. • Thermally designed heat sink (board operating temperature 0° — 70°C). • Commercially designed power bus, 7 ground bus bars, 0.1 uf decoupling capacitors. • Fully tri-state buffered. • Inputs fully low power Shottky Schmitt. Trigger buffered on all address and data lines. • Phantom is jumper selectable to pin 67. • Each 4K hardware or software selectable. • One on board 8-bit output port enables or disables the 32K in 4K blocks. • Selectable port address. • 4K banks can be selected or disabled on power on clear or reset. • Will operate with or without front panel. • Compatible with ALPHA MICRO, with extended memory management for selection beyond 64K. • No DMA restriction. • Low power consumption 2.3 - 2.5 amps. • Fully warranted for 120 days from date of shipment.

ASSEMBLED & TESTED SHIPPING WEIGHT 2 lbs.



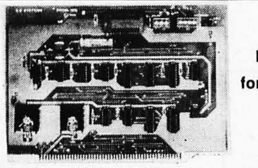
M32 KSS-H (4 MHz)	M32 KSS-L (2 MHz)
List $680	List $650
SALE $560.00	SALE $530.00



VDB-8024 VIDEO DISPLAY BOARD
With on-board Z80 Microprocessor

- S-100 bus Compatible
- Full 80 Characters by 24 Lines Display
- Characters Displayed by High Resolution 7 x 10 Matrix
- Composite or TTL Video Output
- Keyboard Power and Interface
- Forward and Reverse Scrolling Capability
- Blinking, Underlining, Field Reverse, Field Protect and Combinations
- Full Cursor Control
- 96 Upper and Lower Case Characters
- 32 Special Character Set
- 128 Additional User Programmable Characters (Optional)
- On-Board Z80 Microprocessor
- 2K Bytes Independent On-Board RAM Memory
- Glitch-Free Display

	List Price	Sale Price
SDS-VDB-8024 KIT	$370.00	$329.95



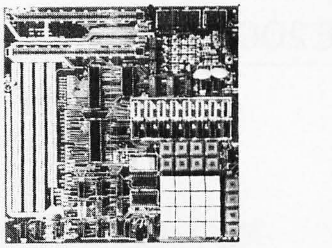
PROM-100
Programming Board for PROM Development

NEW

SD SYSTEMS' PROM-100 is a versatile PROM programming board offering complete EPROM programming capability. The board operates on the industry standard S-100 Bus. Support software verifies the erasure of EPROM and verifies the loaded program. SD SYSTEMS' PROM-100 offers a support-software listing with its operations manual.

- S-100 Bus Compatible
- Programs the Following EPROM s: 2708, Intel 2758, 2716, 2732 and Texas Instruments 2516
- Dip Switch Selection of EPROM type
- 25 VDC Programming Pulse Generated On Board
- Maximum Programming time: 16,384 Bits in 100 Seconds
- Power Requirement: +8VDC at 300 ma.; +16 VDC atr 100 ma.; −16 VDC at 60 ma.
- TTL compatible
- Software Provides for Reading of Object File from SDOS, CP/M or PROM and Programming into EPROM
- Program Verification • Verification of Erasure
- Zero Insertion Force Socket

	List Price	Sale Price
SDS-PROM-100 KIT	$200.00	$175.00



Z80 STARTER KIT
A Complete Microcomputer On A Board

- Z80 CPU with 158 Instructions
- On-Board Keyboard and Display
- On-Board PROM Programmer for Single Voltage PROMS (2716, 2758, TI2516)
- Kansas City Standard Cassette Interface
- Simple Key Controlled Audio Cassette Load and Dump
- Expansion Provision for Mounting Two S-100 Connectors (Sockets Not Included)
- Wire Wrap Area for Custom Circuitry
- Single Step through RAM or PROM
- Memory Examine and Change
- Port Examine and Change
- Z80 CPU Register and Change
- 2K Byte ZBUG Monitor in ROM
- 1K Bytes of RAM (Expandable to 2K Bytes)
- A 4 Channel Hardware Counter/Timer (Z80-CTC)
- Two Bi-Directional 8-Bit I/O Ports (Z80-P10)
- Up to 5 Programmable Breakpoints
- Switch Selectable PROM or Monitor Restart
- Vectored Interrupts provided by Z80-CTC and

	List Price	Sale Price
SDS-Z80 STARTER KIT	$340.00	$279.95

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Terms: Visa, MC, BAC, Check, Money Order, C.O.D. U.S. Funds Only. CA residents add 6% sales tax. Minimum order $10.00 Prepaid U.S. orders less than $75.00 include 5% shipping and handling, MINIMUM $2.50. Excess refunded. Just in case . . . please include your phone no.
Prices subject to change without notice.
We will do our best to maintain prices thru Feb. 1980
phone orders welcome (213) 894-8171, (800) 423-5633
OEM and Institutional inquiries invited.

800-423-5633
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4 MHZ EXPANDORAM II KIT

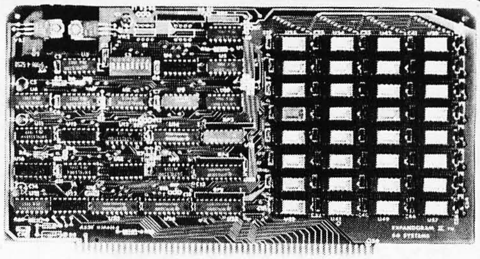
The S-100 Memory Board for the 80's

NEW

SD SYSTEMS' ExpandoRAM II is a state-of-the-art dynamic RAM board with capacities from 16K bytes (4116) to 256K bytes (4164). It operates on the industry S-100 Bus. The ExpandoRAM II's design allows eight boards to operate from the same S-100 Bus. Page mode operation provides the system with the capability of servicing multiple users without RAM interference. Invisible refresh and synchronization with wait states provide greater reliability, and processing speeds up to 4 Mhz.

The ExpandoRAM II is compatible with most S-100 CPU's based on the Z80 microprocessor. When other SD SYSTEMS 200 series boards are combined with the ExpandoRAM II, they create a microcomputer with exceptional capabilities and features.

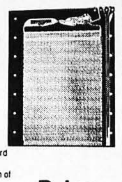
- S-100 Bus Compatible
- Up to 4Mhz Operation
- Expandable Memory from 16K to 256K
- DIP Switch Selectable Boundaries
- Uses 16K (4115) or 64K (4164) Memory Devices
- Page Mode Operation Allows up to 8 Memory Boards on Bus
- Operates with Z80 CPU's
- Phantom Output Disable
- Invisible Refresh (Synchronized with Wait States)



SDS - EXPANDOPRAM II KIT (4116)

	List Price	Sale Price		List Price	Sale Price
16K . . .	$460.00	$295.00	48K . . .	$960.00	$445.00
32K . . .	$710.00	$370.00	64K . .	$1210.00	$520.00

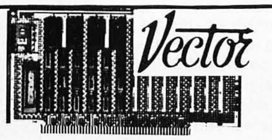
Vector 8803 MOTHER BOARD FOR S100 BUS MICRO-COMPUTERS



- Kit includes 12 tantalum capacitors for +5, +12, —12 buses and insulated mounting spacers.
- Wiring side shown. Component side bare epoxy glass with white markings for component locations.
- G10 epoxy glass board with 2 ounce copper, solder plated and .038 diameter holes for leads.
- Solder mask with solder windows on etched circuits to avoid accidental short circuits.
- Mounts 11 receptacles with 100 contacts (2 rows) on .125 centers with .250 row spacing. Vector part number R681-2; or mounts 10 receptacles plus interconnections to smaller mother board for expansion.
- Includes etched circuits and instructions for option of active, pull-up, or floating terminations.
- Large buses: +5V and GND (10 AMPS), ± 12V or 16V (7 AMPS). Current ratings are per MIL-STD-275 with 10°C rise.
- Fits in Vector-pak enclosures.
- Fits in IMSAI 8080 microcomputer as expander board.

Price: $29.50

Vector 8800V



Universal Microcomputer/processor plugboard, use with S-100 bus. Complete with heat sink & hardware. 5.3'' x 10'' x 1/16''

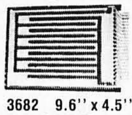
1-4	5-9	10-24
$19.95	$17.95	$15.96

8801-1

Same as 8800V except plain; less power buses & heat sink.

1-4	5-9	10-24
$15.22	$13.79	$12.18

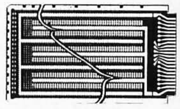
Plugboards



3682 9.6'' x 4.5'' $12.97

3682-2 6.5'' x 4.5'' $9.81

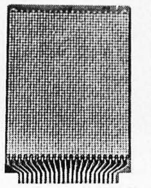
Hi-Density Dual-In-Line Plugboard for Wire Wrap with Power & Grd. Bus Epoxy Glass 1/16'' 44 pin con. spaced .156



3677 9.6'' x 4.5' **$10.90**

3677-2 6.5'' x 4.5'' **$9.74**

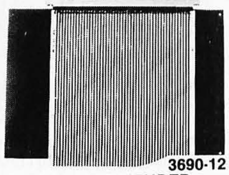
Gen. Purpose D.I.P. Boards with Bus Pattern for Solder or Wire Wrap. Epoxy Glass 1/16'' 44 pin c n. spaced .156



3662 6.5'' x 4.5'' **$8.95**

3662-2 9.6'' x 4.5'' **$11.45**

P pattern plugboards for IC's Epoxy Glass 1/16'' 44 pin con. spaced .156



3690-12

CARD EXTENDER

Card Extender has 100 contacts 50 per side on .125 centers-Attached connector-is compatible with S-100 Bus Systems. **$25.83**

3690 6.5" 22/44 pin .156 ctrs. Extenders $13.17

SALE S-100 BUS EDGE CONNECTORS* SALE



CG 1 (MSA) Style Card Guides 5/$1.00

S100-WWG 50/100 Cont .125 ctrs. 3 LEVEL WIRE WRAP 025'' sq. posts on .250 spaced rows. GOLD PLATED

1-4	5-9	10-24
$4.75	$4.00	$3.75

S100-STG 50/100 Cont .125 ctrs. DIP SOLDER TAIL on 250 spaced rows for VECTOR, IMSAI, CROMENCO mother boards GOLD plated

1-4	5-9	10-24
$4.10	$3.80	$3.50

S100SE 50/100 Cont .125 ctrs. PIERCED SOLDER EYELET Tails GOLD

1-4	5-9	10-24
$5.00	$4.50	$4.00

S100ALT 50/100 Cont .125 ctrs. DIP SOLDER TAIL on 140 spaced rows for ALTAIR motherboards, GOLD plated.

1-4	5-9	10-24
$4.50	$4.25	$4.00

Other Popular Edge Connectors

D2244-5WW 22/44 Cont .156 ctrs.WIRE WRAP tails GOLD.

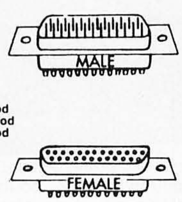
1-4	5-9	10-24
$3.95	$3.70	$3.40

D2244-5SE 22/44 Cont .156 Ctrs.PIERCED SOLDER EYELET tails GOLD plated.

1-4	5-9	10-24
$3.00	$2.60	$2.20

RS232 & "D" TYPE CONNECTORS *

P = Plug-Male S = Socket-Female C = Cover-Hood



PART NO.	DESCRIPTION	1-4	5-9	10-24
DE-9P	9 Pin Male	1.50	1.30	1.20
DE-9S	9 Pin Female	2.15	2.05	1.95
DE-9C	9 Pin Cover	1.50	1.30	1.15
DA15P	15 Pin Male	2.20	2.00	1.80
DA15S	15 Pin Female	3.20	3.00	2.80
DA15C	15 Pin Cover	1.60	1.45	1.30
DB-25P	**25 Pin Male**	**2.90**	**2.60**	**2.50**
DB-25S	**25 Pin Female**	**3.75**	**3.65**	**3.40**
DB51212-1	**1 pc. Grey Hood**	**1.65**	**1.40**	**1.20**
DB1226-1A	**2 pc. Black Hood**	**1.90**	**1.60**	**1.50**
DB110963-3	**2 pc. Grey Hood**	**1.80**	**1.55**	**1.35**
DC37P	37 Pin Male	3.95	3.80	3.60
DC37S	37 Pin Female	5.75	5.50	5.20
DC37C	37 Pin Cover	2.20	1.95	1.75
DD50P	50 Pin Male	4.95	4.75	4.50
DD50S	50 Pin Female	7.50	7.20	6.90
DD50C	50 Pin Cover	2.50	2.20	2.10
D20418-S	Hardware Set (2 pair)	1.00	.80	.70

Connector for CENTRONICS 700 SERIES:
Amphenol 57-30360 for back of Centronics 700 Series printers
1-4—$9.00 5-up—$7.50

1/16 Vector BOARD



.042 dia holes on 0.1 spacing for IC's

Phenolic PART NO.	SIZE	PRICE 1-9	10-19
64P44XXXP	4.5x6.5"	$1.56	$1.40
169P44XXXP	4.5x17"	$3.69	$3.32
Epoxy Glass			
64P44	4.5x6.5"	$1.79	$1.61
84P44	4.5x8.5"	$2.21	$1.99
169P44	4.5x17"	$4.52	$4.07
169P84	8.5x17"	$8.83	$7.95

3 LEVEL GOLD WIRE WRAP SOCKETS*

Sockets purchased in multiples of 50 per type may be combined for best price.



	1-9	10-24	25-99	100-249	250-999
8 pin	.40	.36	.34	.31	.27
14 pin	.44	.43	.41	.39	.37
16 pin	.55	.47	.45	.41	.39
18 pin	.70	.60	.55	.50	.45
20 pin	.90	.80	.75	.65	.62
22 pin	.95	.85	.80	.70	.65
24 pin	.95	.85	.80	.70	.65
28 pin	1.25	1.15	1.00	.95	.90
40 pin	1.65	1.45	1.35	1.20	1.10



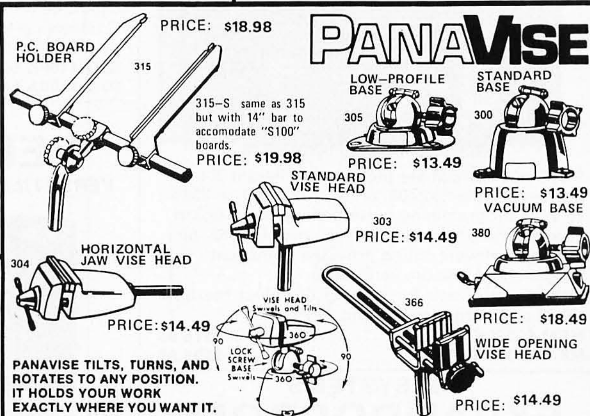
All sockets are GOLD 3 level closed entry. 2 level Tail Low Profile, Tin Sockets and Dip Plugs available. CALL FOR QUOTATION.

3M SCOTCH® BRAND DISKETTES

Part No.	Sides/ Density	Sectoring	Price Box of 10
		8"	
740-OP	1/single	Soft-IBM	$39.95
740/2-OP	2/single	Soft-IBM	$75.00
740-32P	1/single	32	$39.95
740/2-32P	2/single	32	$75.00
741-0	1/double	Soft	$59.00
		5"	
744-OK	1/single	Soft-(TRS-80)	$51.00*
744-10K	1/single	Soft/10	$51.00*
744-16K	1/single	Soft/16	$51.00*

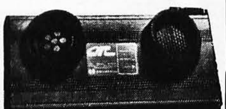
*Price includes Kas-ette/10 Storage Box a $5.00 Value (TRS-80)
"DON'T SETTLE FOR ANYTHING LESS THAN SCOTCH"

PANAVISE



PANAVISE TILTS, TURNS, AND ROTATES TO ANY POSITION. IT HOLDS YOUR WORK EXACTLY WHERE YOU WANT IT.

NOVATION CAT ACOUSTIC MODEM



$174.95 Regular $198.00

- 0-300 Baud
- Bell 103
- Answer, Originate

TRS-80/APPLE MEMORY EXPANSION KITS

4116's RAMS from Leading Manufacturers (16Kx1 200/250ns)

8 for $75.00

Add $3.00 for programming Jumpers for TRS-80 Keyboard

DEALERS CALL FOR 1 PRICING

MEMORY MEMORY

2102LIPC	Low Power 450ns in lots of 25	$1.10
2102AL-2	Low Power 250ns in lots of 25	$1.25
2114-3L	1Kx4 300ns Low Power	8/$50.00
5257-3L	4Kx1 300ns Low Power	8/$55.00
2708	8K 450ns EPROM	8/$65.00 $9.00
2716	16K 5 Volt Only EPROM	$40.00

Vector WRAP POST

for .042 dia. holes (all boards on this page)

T44/C pkg. 100 . . $ 2.34
T44/M pkg. 1000 . . . . . $14.35
A-13 hand installing tool . . . . $ 4.19

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Terms: Visa, MC, BAC, Check, Money Order, C.O.D. U.S. Funds Only. CA residents add 6% sales tax. Minimum order $10.00 Prepaid U.S. orders less than $75.00 include 5% shipping and handling, MINIMUM $2.50. Excess refunded. Just in case . . . please include your phone no.
Prices subject to change without notice.
We will do our best to maintain prices thru Feb. 1980

*SOCKET and CONNECTOR prices based on GOLD, not exceeding $375.00 per oz.

phone orders welcome (213) 894-8171, (800) 423-5633

OEM and Institutional inquiries invited.

ORDER TOLL FREE 1-800-423-5633

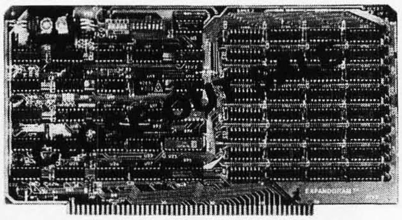
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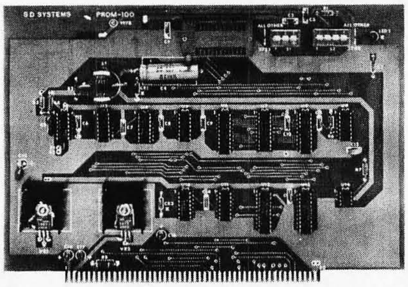
OUR BEST SELLING MEMORY
EXPANDORAM
EXPANDABLE TO 64K USING 4116 RAMS



Interfaces with most popular S-100 boards
Bank selectable; PHANTOM provision
Draws only 5 watts fully populated
Designed to work with Z-80, 8080, and 8085 systems
No wait states required
16K boundaries & protect via dip switches
Kits come with sockets for full 64K
Invisible refresh

MEM-16130K (16K KIT) **$239.95**
MEM-16130A (16K A&T) **$289.95**
MEM-32131K (32K KIT) **$309.95**
MEM-32131A (32K A&T) **$359.95**
MEM-48132K (48K KIT) **$379.95**
MEM-48132A (48K A&T) **$429.95**
MEM-64133K (64K KIT) **$449.95**
MEM-64133A (64K A&T) **$499.95**

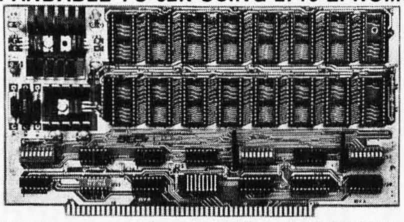
S D SYSTEMS
PROM-100
VERSATILE EPROM PROGRAMMER



S-100 bus compatible (note: board height 7")
Dip switch selects 2708, 2716, 2732, 2758, or 2516's
25 VDC programming pulse generated on board
Programming time only 100 seconds for 16K bits
Support-software listing provided in manual
Program and erasure verification
Software provides for reading of object file from CP/M and programming into EPROM

MEM-99520K (KIT) **$175.95**
MEM-99520A (A&T) **$225.95**

S D SYSTEMS
EXPANDOPROM
EXPANDABLE TO 32K USING 2716 EPROMS



S-100 bus compatible, uses 2708 or 2716 EPROMs
Dip switches allow selection of : each EPROM, 16K or 32K boundary, wait states

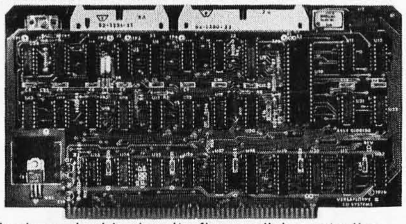
MEM-32220K (KIT) **$149.95**
MEM-32220A (A&T) **$199.95**

GET THE INSIDE TRACK
JADE DOUBLE-D
DOUBLE DENSITY DISK CONTROLLER

Read/write single or **double density,** 8" or 5¼" drives
On board Z-80 insures reliable operation
CP/M compatible in either single or double density
Density is software selectable
Up to 4 single or double sided, single or double density drives may be mixed on the same system
EIA level serial printer interface on board-up to 9600 baud (perfect for despooling operations)
All the hard work of disk access is done by the on board Z-80A and 2K memory, leaving your host CPU free for its normal duties
Uses IBM standard formats for proven reliability
THIS BOARD REALLY WORKS !!!!!!

IOD-1200K (DOUBLE-D KIT) **$285.00**
IOD-1200A (DOUBLE-D A&T) **$349.00**
IOD-1200D (MANUAL ONLY) **$15.00**

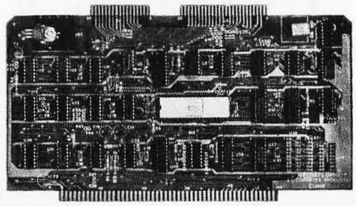
S D SYSTEMS
VERSAFLOPPY II
DOUBLE DENSITY DISK CONTROLLER



Single or double density floppy disk controller
985600 bytes on 8" double sided diskettes
259840 bytes on double sided 5¼" diskettes
S-100 bus (IEEE) standard compatible
IBM 3740 format in single density
8" and 5¼" drives controlled simultaneously
Operates with Z-80, 8080, and 8085 CPU's
Controls up to 4 drives
Vectored interrupt operation optional

IOD-1160K (KIT) **$335.95**
IOD-1169A (A&T) **$385.95**

S D SYSTEMS
VERSAFLOPPY
VERSATILE FLOPPY DISK CONTROLLER



IBM 3740 soft sectored format
S-100 Z-80 or 8080 compatible
Controls up to 4 single or double sided drives
Compatible with all popular disk drives
CP/M compatible
Listings for control software included

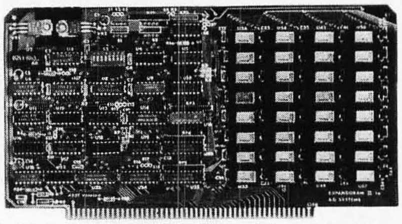
IOD-1150K (KIT) **$189.95**
IOD-1150A (A&T) **$239.95**

NEW 2 OR 4 MHz REV. C BOARD
THE JADE BIG Z
Z-80 CPU BOARD WITH SERIAL I/O PORT

2 or 4 MHz switchable, on-board 2708, 2716, or 2732 EPROM useable in SHADOW mode (full 64K RAM)
Automatic MWRITE generation if no front panel
On-board USART for sync or async RS232

CPU-30201K (KIT) **$159.00**
CPU-30201A (A & T) **$209.00**

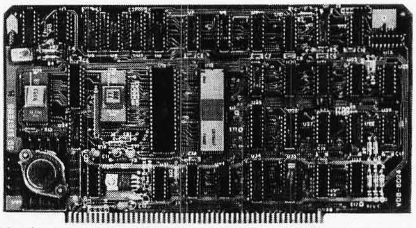
S D SYSTEMS
EXPANDORAM II
4 MHz RAM BOARD EXPANDABLE TO 256K



S-100 bus compatible, up to **4 MHz** operation
Expandable memory from 16K to 256K
Dip switch selectable boundaries
Page-mode allows up to 8 boards on the same bus
Invisible refresh; PHANTOM output disable
Designed to operate in Z-80 based systems

MEM-16631K (16K KIT) **$295.95**
MEM-16631A (16K A&T) **$345.95**
MEM-32632K (32K KIT) **$369.95**
MEM-32632A (32K A&T) **$419.95**
MEM-48632K (48K KIT) **$444.95**
MEM-48632A (48K A&T) **$494.95**
MEM-64632K (64K KIT) **$519.95**
MEM-64632A (64K A&T) **$569.95**

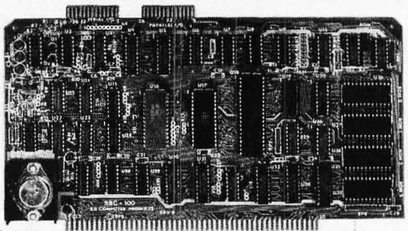
S D SYSTEMS
VDB-8024
80 X 24 I/O MAPPED VIDEO BOARD



80 character by 24 line display, 7 X 10 dot matrix
Composite or seperate TTL video outputs
On-board keyboard interface with power
On-board Z-80 and 2K RAM
Blink, underline, reverse, protect, up/down scroll
Upper/lower case characters, 32 special characters
Optional 128 user-programmable characters

IOV-1020K (KIT) **$329.95**
IOV-1020A (A&T) **$389.95**

S D SYSTEMS
SBC-100/200
2 OR 4 MHz SINGLE BOARD COMPUTER



S-100 bus compatible Z-80 CPU
1K of on-board RAM
4 EPROM sockets accomodates 2708, 2716, or 2732
One parallel and one serial I/O port
4-channel counter timer chip (Z-80 CTC)
Software programmable serial baud rates

CPC-30100K (2 MHz KIT) **$249.95**
CPC-30100A (2 MHz A&T) **$299.95**
CPC-30200K (4 MHz KIT) **$289.95**
CPC-30200A (4 MHz A&T) **$339.95**

ADVANCED COMPUTER PRODUCTS

APPLE II PLUS**

(limited offer) 16K only **$990.00**

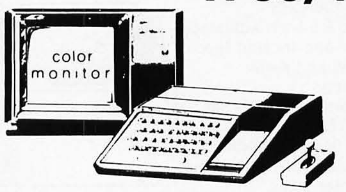


Disk I	475.00	Firmware Card	175.00
Disk II w/Controller	575.00	Proto Card	22.00
Pascal Card	475.00	M & R Modulator	29.95
Parallel Printer Card	165.00	Sanyo Cassette	54.96
Communications Card	210.00	16K Upgrade Kit	69.95
Business Software Pkg.	625.00	Apple Radio Car	159.00
10 Megabyte Hard Disk	4695.00	8" Floppy Controller	350.00
D.C. Hayes Modem	349.95	Heuristics Speechlab	179.95

FLOPPY DISK DRIVES

MPI B51-5¼", 40 tracks	279.00	PERSCI Model 277 Dual	1195.00
Shugart SA400-5¼" 35 tracks	295.00	WANGO/SIEMENS 5¼" Drive	290.00
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Siemens Shugart Compatible Model 120-BD	449.00	WANGO/SIEMENS 282 Dual 5¼"	395.00

TI 99/4



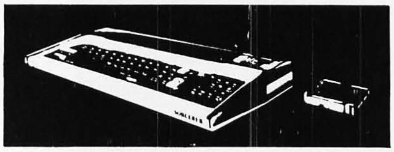
Finally! We've heard so much about it and we are proud to offer:
• Color • Up to 72K • 16 Color Graphics • Music • Sound • Solid State Software

LIMITED QTY: **$1150.00**

TRS-80/APPLE

MEMORY EXPANSION KITS
4116's
16K (200/250 ns.)
8 pcs. for **$69.95**
w/instructions & jumpers.

EXIDY SORCERER



$1099 w/16K
$1249 w/32K
$1449 w/48K

User programmable or use cartridges. Combines the desirable features of the PET, APPLE and TRS-80 into a complete expandable computer system.

★★ I/O expansion kit $149.00
★★ Vista Exidy Dual Floppy Add-on $1199.00

★★ New Word Processing Pac .... $ 250.00
★ INCLUDES:
Keyboard & enclosure
90 day Warranty
MICROSOFT BASIC
Video & Cassette Cable
Complete Documentation
★★ S100 Expansion Module .... Add $299.00
★★ Cassette recorder .... Add $44.95
★★ Sanyo 9" Monitor .... Add $169.95

HICKOK LX303

$74.95



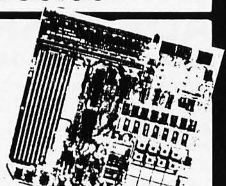
.5%, 3½ digit 19 Range DVM, ½" LCD displays runs 200 hrs on 1 battery. 10 Meg Ohm Input. 1 yr. guarantee, made in U.S.A., test leads included.

Available Accessories

RC-3	115V AC Adapter	**$7.50**
CC-3	Deluxe Padded Vinyl Carrying Case	**$7.50**
VP-10	X10 DCV Probe Adapter/ Protector 10 Kv	**$14.95**
VP-40	40 Kv DC Probe	**$35.00**
CS-1	10 Amp Current Shunt	**$14.95**

Z80 Starter Kit

$249



A Complete Microcomputer on a Board

★ Z80 Central Processing Unit with 158 Instructions.
★ On-Board Keyboard and Display.
★ Kansas City Standard Cassette Interface.
★ PROM Programmer Built on-board.
★ Expansion provision for two S-100 Connectors.
★ Wire Wrap area for custom circuitry.

. . . and it's COLOR "The Compucolor II"

SALE $100.00 OFF

. . . a personal colorgraphics system for the modern computer man . . .



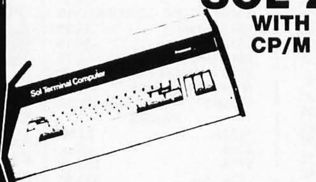
★ Color Graphics 13" Color CRT
★ Proven 8080A CPU System
★ 16K Extended Disk Basic
★ Up to 117* Key Keyboard
★ Up to 32K* RAM
★ Minidisk Drive 51.2K Bytes/Side

*option

Model 3 w/8K, 72 Key Keyboard, RS232	SALE TAKE $100.00 OFF	$1595.00
Model 4 w/16K, 72 Key Keyboard, RS232		$1895.00
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Options: 101 Key Keyboard		Add $150.00
117 Key Keyboard		Add $225.00
Formatted Diskettes		2/$9.95
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Diskette Library Inc. Hangman, Othello, Math, Chess, Startrek, Blackjack, Cubic Tic Tac Toe, Finance Vol. I, Finance Vol. II, Bonds and Securities, Assembler, Text Editor, Personal Data Base. $19.45 $29.00

SOL-20 WITH CP/M

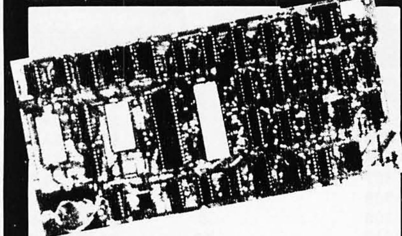


Now you can use the SOL-20 and take advantage of the unlimited CP/M based software that is available.

NEW $1095.00
USED $795.00

SOL nKRA (expandable to 65K) RAM boards. Assembled and socketed w/o memory, data delay and proms. Only $139.95

Data Delay Lines $29.95
Sol-20 Keyboards .... Only $139.95
Sol Keyboard Enclosure $44.95



VDB-8024 Video Display Board

$319 KIT

With On-Board Z80 Microprocessor

★ Full 80 Characters by 24 lines display.
★ Characters displayed by High Resolution 7 x 10 Matrix.
★ Keyboard Power and Interface.
★ Composite Video Output.
★ Separate TTL Level Synchronization and Video Outputs.
★ 2K Bytes Independent On-Board Memory.
★ On-Board Z80 Microprocessor.
★ Glich Free Display.

ATARI 800 & 400



ATARI 800 **$899.00**
Includes:
Computer Console
BASIC Language Cartridge
Education System Master Cartridge
BASIC Language Programming Manual
800 Operator's Manual w/Notebook
Atari 410 Program Recorder
Guide to BASIC Programming Cassette
8K RAM Module
Power Supply
TV Switch Box

ATARI 400 **$499.00**
Includes:
Computer Console
BASIC Language Cartridge
BASIC Language Programming Manual
400 Operator's Manual w/Notebook
Power Supply
TV Switch Box

KIM-1



Now only $179.00
★★ Power Supply .... Add $59.95
★★ Cassette Recorder .... Add $44.95
★★ Sanyo 9" Monitor .... Add $169.00
Add enclosure $29.95.

AIM 65



$375.00
★ On Board 20 column alphanumeric printer

w/1K RAM $375.00
w/4K RAM $450.00
Assembler ROM ... Add $85.00
BASIC IN ROM ... Add $100.00
Power Supply .... Add $69.95
Enclosure .... Add $49.95

SYM-1

IN STOCK

Reg. $269.00
Now $219.00



★ KIM-1 Compatible
★ 4K ROM Monitor
★ 1K Bytes 2114 RAM
★ 65K Memory Expansion
★ User EPROM 2716
★★ Power Supply .... Add $59.95
★★ Cassette Recorder .... Add $44.95
★★ Sanyo 9" Monitor .... Add $169.95
SYM Enclosure $39.95
School & group discounts available.

Buy now and receive $100.00 worth of discount coupons: i.e.,
★ SRM-1 1K Static RAM exp., reg. $42.00 .... disc. $32.00
★ PEX-1 I/O Port, reg. $60.00 .... disc. $50.00
★ SYM BAS-1 Basic ROM (Microsoft), reg. $159.00 .... disc. $109.00
★ KTM-2 CRT/TV Keyboard, reg. $349.00 .... disc. $319.00

SBC-100

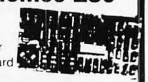
Z-80 based singleboard computer by SD Systems

★ 1K RAM
★ RS232 port
★ 4 channel counter/timer

Kit $239.00
Assembled $369.00

Cromemco Z80

4 MHz Computer Single Card



Cromemco's Single Card Computer is a complete computer which brings the power of the Z-80 and the flexibility of the S-100 bus to the dedicated computer environment.

SCC-W (Assembled) **$450.00**

Processor: 4MHz Z-80
Instruction Set: 158 instructions incl. the 78 instructions of the 8080
ROM Capacity: 8K Bytes located from address 0000 to 1FFF
ROM Type: Intel 2716 PROM or equivalent.
RAM Capacity: 1K Bytes located from address 2000 to 23FF
RAM Type: 4045, Static

RCA COSMAC VIP



NEW LOW PRICE **$249.00**
Assembled. *Regular price* $299.95
w/Sanyo 9" Monitor $169.95

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1980 CATALOG AVAILABLE SOON

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STATIC RAM BOARDS

Now, just more than 1½¢ per bit!

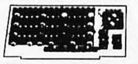
S-100 32K (uses 2114)

ASSEMBLED		Kit	
450ns.	599.00	450ns.	539.95
250ns.	699.95	250ns.	599.95

Bare Board 49.95
Bare Board w/all parts less mem. 99.95

RAM 65 (16K Static w/Memory Management)
2 MHz $299.00 — 4 MHz $399.00

RM 16 (16K Static w/Bank Select)
2 MHz $249.00 — 4 MHz $329.00
(16K Assembled & Tested Using Low Power 2114's)



LOGOS I 8K

ASSEMBLED		KIT	
450 ns.	149.95	450ns.	125.95
250ns.	169.95	250ns.	149.95

Bare PC Board w/Data $21.95
"Special Offer" Buy (4) 8K 450ns. Kits $117.00

TRS-80 ADD-ON DISK



NEW
- VISTA V-80 MINIDISK
- ★ 23% More Storage Capacity - 40 Tracks
- ★ 40 track patch free
- New Double Density Expansion Module $239.00
- 2 Drive Cable Add $29.95
- 4 Drive Cable Add $39.95

395.00

S-100 ADD-ON MINI-DISK
- VISTA V-200 Minifloppy System
- ★ 204K Byte Capacity
- ★ Double Density Drive
- ★ CP/M & Basic "E"
- ★ Double Density Controller
- ★ Case and Power Supply
- ★ Assembled & Tested Ready to Plug In
- ★ EXIDY, HORIZON, SOL, etc. Compatible

V-200 699.00

S-100 ADD-ON DISK SUBSYSTEM
- VISTA V-1000 Floppy Disk Subsystem
- ★ (2) Shugart 8" Disk Drives
- ★ Case with Fan & Power Supply
- ★ VISTA Floppy Disk Controller Card
- ★ CP/M Disk Operating System
- ★ Fully Factory Assembled & Tested

V-1000 1699.00

LOW-COST ADD-ON DISK SUBSYSTEM KIT
- ★ (2) 8" Drives
- ★ VISTA Floppy Controller Card
- ★ Power Supply and Interface Cable
- ★ CP/M Disk Operating System
- ★ Box of 10 Diskettes

Low Cost Sys. 1299.00

IMS STATIC RAM BOARDS
★ Memory Mapping ★ Low Power ★ Phantom ★ Assembled & tested — $69⁹⁵
Recommended by Alphamicrosystems

	250 ns.	450 ns.
8K Static	$209.00	$189.00
16K Static	$449.00	$399.00
32K Static	$799.00	$699.00

ANADEX PRINTER
Model DP-8000 compact, impact, parallel or serial. Sprocket feed, 80 cols, 84 lines/min., bi-directional.
New only $895.00



FLOPPY DISKETTES
LOW PRICE TOP QUALITY DISKETTES
★ 5¼" Minidiskettes ★
Softsector, 10 Sector, 16 Sector
$4.25 Each, 10/39.95
★ 8" Standard Floppy Disks ★
Soft Sector, Hard Sector
$4.50 Each, 10/41.95
*Add 4.95 for 10 Pack in Deluxe Disk Holder

MOTOROLA EXORCISER COMPATIBLE
- 9600 MPU Module w/6802 CPU $495.00
- 9601 16 Slot Mother Board 175.00
- 9602 Card Cage (19" Retma Rack Mount) 75.00
- 9603 8 Slot Mother Board 100.00
- 9604 Switchmode System Power Supply 250.00
- 9610 Utility Prototyping Board 36.00
- 9616 Quad 8K Eprom Module .... ***
- 9620 16 Channel Parallel I/O Module 295.00
- 9622 Serial/Parallel I/O Combo .... ***
- 9626 8K Static RAM Module 295.00
- 9627 16K Static 450ns 495.00
- 9630 Card Extender 68.00
- 9640 Multiple Programmable Timer (24 Timers) 395.00
- 9650 8 Channel Duplex Serial I/O 395.00
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6800 BARE BOARDS

9620-0	$45.00	9603-0	27.00
9626-0	45.00	9600	55.00
9650-0	45.00	96103	55.00
9601-0	50.00	96702	55.00

Also AMI EVK System in Stock

APPLE/EXIDY/EXPANDO TRS 80 16K-UPGRADE KIT
- ★ 16K with Jumpers & Instructions for either Level I or Level II $69.95
- ★ 16K for Apple II Upgrade $69.95
- ★ Special: TRS80 Schematic .... $ 4.95
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- ★ Expansion Interface Connector ... 7.95

EXPANDORAM II MEMORY KITS
★ Bank Selectable ★ Uses 4116 200 ns.
★ Write Protect ★ Power 8VDC, ±16VDC
★ Phantom ★ Up to 4 MHz
Expando 64 Kit (4116)

16K	$248.95	48K	$439.00
32K	$358.00	64K	$519.00

FROM INTEGRAL DATA SYSTEMS
MODEL 440 "THE PAPER TIGER"



9.5" adjustable tractor feed, parallel & serial I/O, 132 columns, software selectable character size, 110, 300, 600, 1200 baud, to 198 cps.. $995.00
Graphics option w/2K buffer add $199.00

TASA touch activated solid state KEYBOARD



- Full 128 position 8-bit ASCII
- 3 color code, 55 positions
- Immune to static charge
- Low power

Only.......89.95 Optional stand......15.00

UV "Eprom" Eraser



Model UVs-11E $69.95
Holds 4 Eprom's at a time. Backed by 45 years experience.
Model S-52T...$265.00
Professional Industrial Model

TARBELL FLOPPY INTERFACE
★ Z80/8080 S 100 Compatible ★ Uses CPM
- Assembled for Shugart .... **SALE $259.95**
- Assembled Other Drives $269.95
- Kit $179.95
- Bare Board .... $39.95 (Doc. Add $10.00)

Note. For CPM Add $70.00. Documentation Add $20.00
- Vista Double Density 5¼" Controller Assem. $299.00
- SD Versa Floppy Kit II $299.00
- SD Versa Floppy Assembled II $389.00
- Tarbel Cassette I/O Kit $115.00
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- VISTA Floppy Controller 8" (Shugart Comp.) $259.95

NEW CENTRONICS 730 PRINTER
WOW $945.00
Uses any paper roll, fanfold, single sheets, 96 character ASCII, 7 x 7 dot matrix, 50 CPS, RS232 or parallel I/O

Z-80/Z-80A/8080 CPU BOARD
- ★ On board 2708 ★ 2708 included (450ns.)
- ★ Power on jump ★ completely socketed
- ★ Z-80 Assembled and Tested $185.00
- Z-80 Kit $129.95
- Z-80 Bare PC Board .... $ 34.95
- ★ For 4MHz Speed Add $15.00
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- 8080A Assembled $149.95

S-100 MOTHERBOARD SPECIAL
8 slot expandable w/9 conn.
reg $69.95 .... NOW $52.95

SIEMEN'S FLOPPY SALE



- Special buy while supply lasts.
- 8" Drive with Double-Density
- 90 Day Warranty **$449.00**

ACOUSTIC MODEM
NOVATION CAT™
0-300 Baud
Bell 103
Answer, Originate $189.00



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6800 Programming	~~8.50~~	7.75
Z80 Programming	~~8.50~~	7.75
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Beginners Glossary & Guide	~~6.95~~	5.95
Peanut Butter & Jelly Guide to Computers	~~7.95~~	6.95
8080 Machine Language Programming	~~7.95~~	6.95
Home Computers Vol. I Hardware	~~7.95~~	6.95
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Z-80	**14.95**
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2650	18.95
CD1802	17.95
8080A	9.95
8080A-4MHz	19.95
SALE 8085	**19.95**
8008-1	14.95
2901	12.95
2901A	19.95
TMS 9900JL	49.95
CP1600	39.95
6502	11.50
6502A	19.95
IM6100	29.95
6800	13.95
6802P	24.95
8035	19.95
8755	49.95
8748	69.95
6809	$ CALL
8086	$ CALL

SUPPORT DEVICES

AM9511 Arith Processor	$195.00
AM 9511-1 300 ns	245.00
AM9517 DMA Controller	71.95
AM9519 Universal Interrupt	24.95
3881 (Z80 PIO)	9.95
3881-4 (4MHz)	14.95
3882 (Z-80 CTC)	9.95
3882-4 (4MHz)	14.95
3883 SIO	29.95
3884 DMA	49.95
8205 74S138 Decoder	2.95
8212 8 bit I/O	2.50
8214 Priority Int	4.50
8216 Bus Driver	2.50
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5261	1.95	1103	1.95
5262	1.95	4008L	4.95
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21L02 250ns	1.59	1.55	1.45
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2.097152MHz	5.85	13.0MHz	4.95
2.4576MHz	5.85	14.31818	4.95
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4.0MHz	4.95	18.432MHz	5.95
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4.91520MHz	5.95	22.1184MHz	5.95
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FND 507/510 (CA) .500" Red	.99
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HP5082-7731 (CA) .300" Red	.99
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16 Pin W.W.	.38	16 Pin S.T.	.22
18 Pin W.W.	.60	18 Pin S.T.	.31
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22 Pin W.W.	.93	22 Pin S.T.	.35
24 Pin W.W.	.85	24 Pin S.T.	.41
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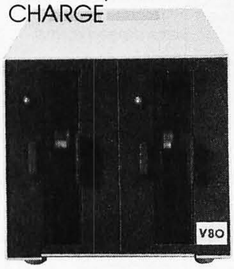
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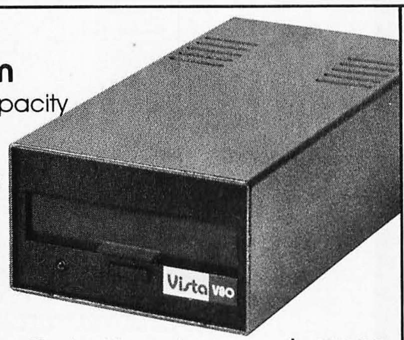
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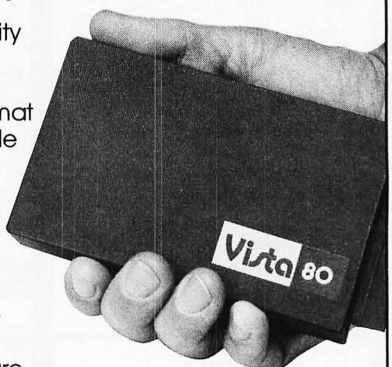


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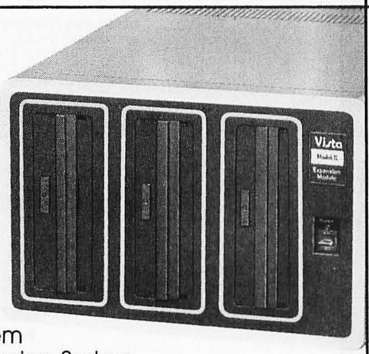
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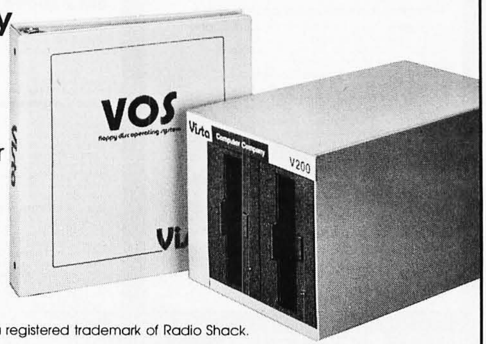
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FOR SALE: Three Heath H11 (or DEC PDP-11/03) static memory boards 4 K by 16. Practically new. $200 each or $575 for all three. M Lowenstein, 79 Larkspur Rd, Stamford CT 06903, (203) 853-7856.

FOR SALE: Magazine sets: BYTE issue #1 to issue #16, *Creative Computing* volume 1 #4 to volume 2 #6, *Kilobaud* issue #1 to issue #12, *Microtrek* volume 1 #1 to volume 1 #2, and *Personal Computing* volume 1 #1 to volume 1 #6. Excellent condition. Please quote offer. F J Scavo, 1811 Court St, Syracuse NY 13208.

FOR SALE: Three Digital Group 8 K memory boards. 450 ns. Very reliable. $140 each. M S Judy, 6401 Hamilton Av, Cincinnati OH 45224, (513) 542-2787.

FOR SALE: Heathkit computer system. Includes H9 video terminal, H8 computer with 8 K memory, serial input/output (I/O) cassette interface, all manuals and cables. Less than one-year-old. $900 for entire system. B Helsel, POB 35, Cudahy WI 53110.

FOR SALE: Heathkit factory assembled and working H11 system (equivalent to LSI/PDP-11), with full memory and interfaces plus H10 paper-tape reader punch. Total cost over $3400, best reasonable offer accepted. Mr Block, POB 231, Hallandale FL 33009, (305) 456-6209.

TRS-80 USERS: Tiny-c and Assembler programming bulletin. Send SASE for information. Rob Varty, 2193 Haygate Cr, Mississauga Ontario, CANADA L5K 1L7.

FOR SALE: Four printers with keyboards ($395 each), reconditioned Singer, dot-matrix impact, 80-character ASCII, 110/300 bps, asynchronous, RS-232 interface, friction or pin feed. M Osedo, 1367 Nanawale Pl, Kailua HI 96734.

FOR SALE: TI 751 Baudot RO thermal printer. New printhead, manuals, not working; $150. RCA Cosmac-based video game as sold by Radio Shack; $50. Ralph Droms, Whitmore Lab, University Park PA 16802.

FOR SALE: Sell or trade Heath H8 mainframe, H8-1 4 K memory, H8-2 parallel input/output (I/O), H8-5 serial and cassette I/O, Godbout Econoram VI 12 K memory, and system software. Want $750 or OSI 1P with 12 K, C2-4P with 8 K, or C2-8P with 4 K. Also have Digital Group TVC-64 for $100 and Radio Shack ASCII keyboard for $25. Robert Howarth Jr, RFD #1 POB 36, Lisbon NH 03585, (603) 838-6469.

FOR SALE: Line printer, Tally T-2200, 200 lines per minute, 132 columns, 5 by 7 matrix, up to six copies, adjustable tractors, 6/8 lpi, 8-channel VFU, parallel interface. Cost $5000, asking $1600. Also available: warranty, service contract, other interfaces. John Marshall, POB 242, Renton WA 98055, (206) 226-0981.

FOR SALE: Poly 88 system, 32 K programmable memory, 3 K erasable read-only memory, 16 by 64 video with graphics and hardware scroll, keyboard, real-time clock, serial port, high-speed cassette, 9 inch monitor, documentation, and software; $1700 Canadian. North Star FPB; $275 Cdn. input/output (I/O) board with 2708 programmer, three parallel ports, two digital-to-analog (D/A) converters, 16-channel analog-to-digital (A/D) converter, sockets for 8 K programmable memory; $100 Cdn. Michael Dunn, 45 Livingston Rd #501, West Hill Ontario, CANADA M1E 1K8, (416) 266-1635.

FOR SALE: TRS-80 Level 1 microcomputer. Only seven months old. Voice synthesizer and manual included. Eighteen popular software and game programs also included. Computer in great condition. Keyboard, cassette recorder, and video display are also included. Demonstration tape included with voice synthesizer. $1211. Rob Wiley, 1009 S Sterling Av, Tampa FL 33609.

FOR SALE: ELF II system with two 4 K memory boards (factory tested), Giant Board (factory tested), ASCII keyboard, AP-1 5 A power supply (± 8 V DC, 20 V AC/PP), RF modulator, Tiny BASIC cassette, complete documentation. Main board may have one or more defective integrated circuits. Will sell for $275. R C Saunders, 8902 River Rd, Richmond VA 23229, (804) 740-8071.

WANTED: TRS-80 business software disks. I want to purchase programs for business applications at an affordable cost. They can also be in TRS-CPM version or TRS-Microsoft-FORTRAN. Douglas Gilson, Rua Sambaiba 516 Leblon, Rio de Janeiro, BRAZIL.

FOR SALE: Digital Group system, 30 K random access memory, 4 K erasable-programmable read-only memory with custom monitor/debugger, dual Phi-Decks, CDC floppy, Sylvania 12-inch video display, custom front panel, paper-tape reader, interfaces for audio cassette, Tally printer, and programmer; $2200. Optional electronic pinball machine; $400. Bought a larger system. J Kalafatas, 483 Park St, N Reading MA 01864, (617) 275-1800 ext 446 days.

WANTED: Information on Electronics Information Services (EIS) Model #ET-39 Telewriter. Mike Middleton, 1713 W Eva, Phoenix AZ 85021.

FOR SALE: Digital Group four-board system with 10 K random access memory, four PI/Os, video and cassette interface, large mother board, and all documentation. Includes power supplies (5 V at 12 A, 12 V and 5 V at 1 A) and ASCII keyboard. Bought for $1150, will sell for $750 or best offer. Marvin Jones, 2600 NW 30, Oklahoma City OK 73112.

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FOR SALE: Friden Flexowriter Model SPD. Includes parallel interface, but circuit needs minor work. Relays have been stripped, but will be included in the package. Friden schematics included. $100. John Kane, 2193 Charles Dr, Stevensville MI 49127, (616) 429-8353.

WANTED: Any or all copies of Processor Technology's ACCESS newsletter. Peter Wayner, 37 Grandview Dr, Latham NY 12110.

FOR SALE: SwTPC 6800 computer system assembled. Includes: MP-68 processor, 8 K random access memory, MP-S, MP-L, AC-30, CT-1024, two Superscope C-101A cassette decks, 4 K and 8 K BASIC tapes, Motorola K9TS-460Q video monitor/TV, Expandor Model 123P Black Box printer, custom walnut, leather, and acrylic case, complete system documentation. Asking $1950 plus shipping. R H Gay, 48 Maine St, Brunswick ME 04011, (207) 725-5835.

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FOR SALE: RCA Cosmac VIP assembled with video modulator. All in good working condition. All documentation. $160. Philip Best, 19 Brookside Ln, Mansfield Center CT 06250, (203) 429-5633.

FOR SALE: Centronics Micro Printer, RS-232, electrographic printing, 4.6 inches wide; 20,40,80 characters per line; with twenty rolls of paper, $350 or offer. C Looney, 3406 Notre Dame St, Hyattsville MD 20783.

FOR SALE: Electronic Systems Apple II serial input/output (I/O). Assembled and tested. RS-232 input and output; up to 30,000 bits per second (bps). Plugs into Apple. Software routine included. $45. Bill Carlquist, 6253 Hollywood Blvd Suite 202, Hollywood CA 90028, (213) 461-4643.

FOR SALE: Heathkit IG-102 signal generator 100 KC to 110 MC, $60 or best offer. Bell and Howell O-Scope single trace with Heathkit probes, $150 or best offer. Heathkit how to use programs for signal generator and VTVM, $30 each or best offer. Full documentation with above. Brian Hummert, 96 Hollywood Dr, Middletown PA 17057, (717) 939-7646 Mon-Wed 5:00-9:00 ET.

FOR SALE: Four Phi-Decks dress cabinets and Digital Group controller. Asking $700. Peter Bornstein, 120 Ocean Pky, Brooklyn NY 11218, (212) 438-0949.

WANTED: Early issues of BYTE up to September 1976. Please send invoice (needed for Exchange Control) stating price. R L Bissessar, 52 Joyeau St, Curepe Trinidad, TRINIDAD AND TOBAGO, West Indies.

FOR SALE: Very large personal book collection. Subjects include electronics (engineering and technical levels), microcomputers, reference books, college texts, self-study courses, aviation, etc. Send 25¢ and SASE for complete listing. Also for sale, all new parts and chassis for unregulated power supply. $+5$ V at 25 A, -5 V at 3 A, $+/-12$ V at 3 A. Worth over $60. You pay $25 plus shipping. William Blair, POB 81042, DMAFB AZ 85707.

SWAP: OSI Challenger II owner willing to swap programs and information. Have a variety of programs from *101 Computer Games, 24 Tested, Ready-To-Run Programs In Basic*, etc. Most 8 K but some will run in 4 K. (I have Assembler and Extender Monitor so I can run and to some extent modify machine-language programs.) Barry L Beal, RFD #1 POB 160, Machias ME 04654.

WANTED: Computerized options markets (C B O E, etc) and their underlying stocks are my interest, including multiple regression analysis, simulation, trading systems development, and computer interface with a securities quotation machine. I would like to correspond with those interested in trading ideas, programs, data bases, etc. J Spillane, Rd 1 POB 138, Sicklerville NJ 08081.

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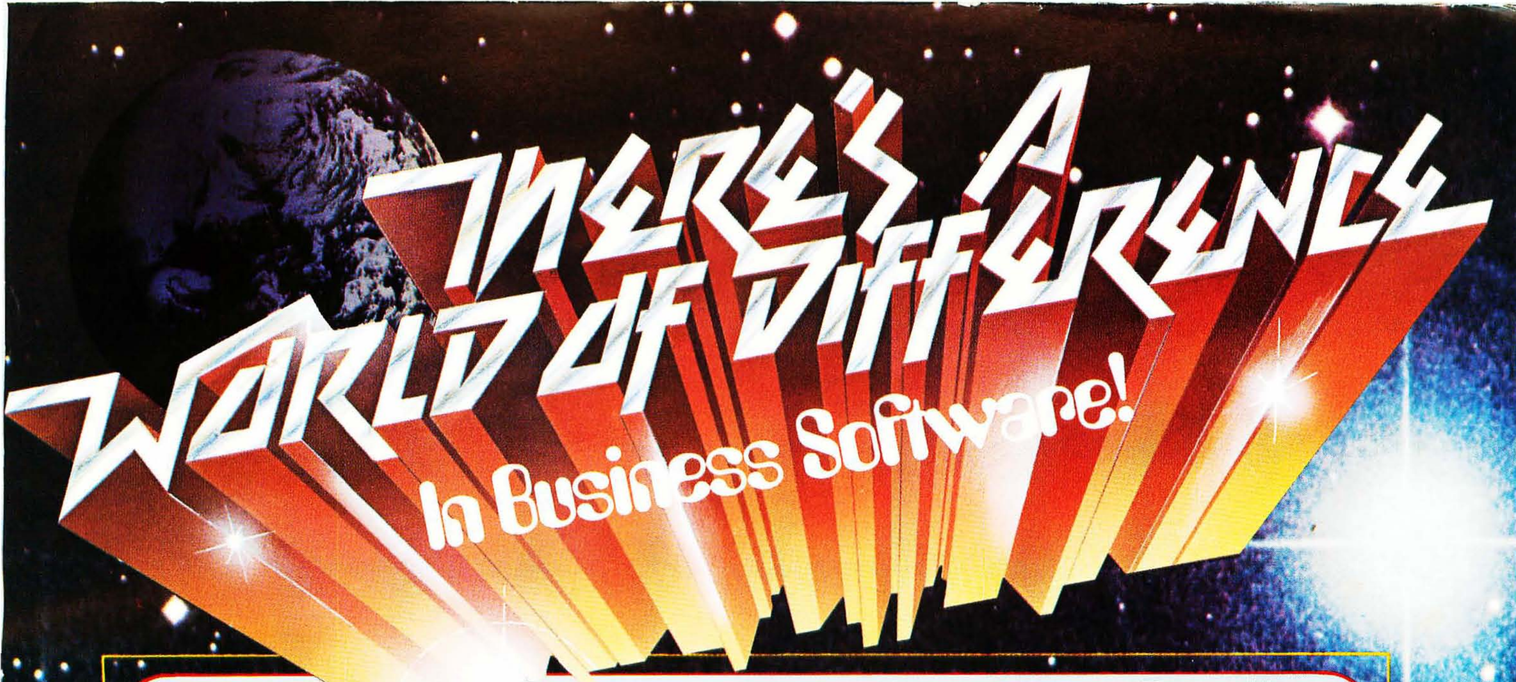
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Ciarcia - Highlight of November Games

It was a close race, but Steve Ciarcia won by a nose in the last lap of the November BOMB for his article "The Intel 8086," (page 14). But so close behind were Macdonald and Gursel with "Solving Soma Cube and Polyomino Puzzles," (page 26) that the judges decided to award first place to both teams. Amazingly enough, the same close race was run for second place which will be awarded both to Gary S Sivak for "A Special Spacecraft Simulator" (page 104) and "Alpha-Beta Pruning" by Dr Maurer, (page 84). Standard deviations for all four articles were between 1.12 and 1.10. ■



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